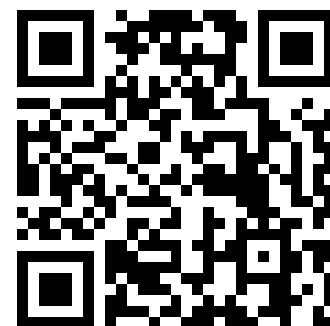


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FOR THE  
FIRST SESSION OF THE FORTY-NINTH CONGRESS.

1885-'86.

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1886.





49TH CONGRESS, }  
1st Session.

HOUSE OF REPRESENTATIVES.

{ Ex. Doc.  
No. 18.

REPORT OF THE SUPERINTENDENT  
OF THE  
U. S. COAST AND GEODETIC SURVEY  
SHOWING  
THE PROGRESS OF THE WORK  
DURING THE  
FISCAL YEAR ENDING WITH  
JUNE, 1885.

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WASHINGTON:  
GOVERNMENT PRINTING OFFICE.  
1886.



FEBRUARY 18, 1886.

*Resolved by the Senate (the House of Representatives concurring),* That there be printed 3,000 extra copies of the report of the Superintendent of the Coast and Geodetic Survey, showing the progress made in said Survey during the year ending June 30, 1885, for distribution by said Superintendent.

Adopted in House July 17, 1886.

ii

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1884/85

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

*The report of the Superintendent of the Coast and Geodetic Survey showing the progress made in that work during the last fiscal year.*

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DECEMBER 17, 1885.—Laid on the table and ordered to be printed.

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TREASURY DEPARTMENT,  
December 12, 1885.

SIR: In compliance with section 4690, Revised Statutes of the United States, I have the honor to transmit herewith, for the information of Congress, a report addressed to this Department by F. M. Thorn, Superintendent of the Coast and Geodetic Survey, showing the progress made in that work during the fiscal year ending June 30, 1885, and accompanied by a map illustrating the general advance in the operations of the Survey.

Respectfully yours,

D. MANNING,  
Secretary.

To the SPEAKER OF THE HOUSE OF REPRESENTATIVES.

iii

8886



## ABSTRACT OF CONTENTS OF REPORT.

Report of progress of the work of the Coast and Geodetic Survey for year ending June 30, 1885, submitted, p. 1.

PART I, pp. 2-13.—*Résumé* of work prosecuted, p. 2. General statement of progress in field work on Atlantic coast, pp. 2-4; on Pacific coast, p. 4; in the interior States, p. 4. Special operations, p. 4. Office work, pp. 4-5. Discoveries and developments, p. 5. Special scientific work, pp. 6-7. The secular variation and geographical distribution of the magnetic dip and intensity in United States, p. 6. Adjustment and reduction of the Davidson quadrilaterals, p. 6. Geographical positions and heights of upwards of one thousand stations in the State of Massachusetts, and geographical positions of about three hundred stations in the State of Rhode Island, p. 6. A plea for a light on Saint George's Bank, p. 7. Comparison of transverse sections of the Delaware River between old Navy-yard and east end of Petty's Island, as derived from the surveys of 1819, 1843, and 1878, p. 7. Harmonic analysis of the tides at Governor's Island, New York Harbor, p. 7. Explanation of estimates pp. 8-9. Estimates, in detail, pp. 9-13.

PART II, pp. 14-77.—*Field and office work, progress in—*

SECTION I.—Topography of Machias Bay entrance, Machias port, and the coast to the eastward, pp. 14, 15. Topography of Chandler's Bay and Englishman's Bay, coast of Maine, p. 15. Hydrographic survey of Narraguagus River from Millbridge to Cherryfield; of Harrington River, including Flat and Back Bays, and of Pleasant River to Addison, pp. 15, 16. Topographical survey in the vicinity of Prospect Harbor, Gouldsboro', Me., and re-survey of Bar Harbor, Mount Desert Island, Me., pp. 16, 17. Record of observations with self-registering tide-gauge continued and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay, p. 17. Hydrographic examinations off the coasts of Maine, New Hampshire, and Massachusetts, p. 17. Continuation of the triangulation of the State of New Hampshire, pp. 17, 18. Stations occupied for continuing the triangulation of the State of Vermont, p. 18. Trigonometrical operations in aid of a topographical survey of the State of Massachusetts, pp. 18, 19. Hydrographic examinations off the coasts of Massachusetts and Rhode Island, pp. 19, 20. Magnetic observations at Providence, R. I., and on Coaster's Harbor Island, Narragansett Bay, pp. 20, 21. Hydrographic examinations in the approaches to Newport, R. I., p. 21. Tidal observations at Providence, R. I., p. 21.

SECTION II.—Topographical re-survey of the northeastern coast of Long Island, in the vicinity of Gardiner's Bay, Shelter Island, and Greenport; also of the north shore of the Sound from Darien, Conn., westward, pp. 21, 22. Continuation of the topographical re-survey of the north shore of Long Island to the west of Greenport, p. 22. Hydrographic examinations off Terry Point and Rocky and Horton's Points, Long Island, p. 22. Topographical re-surveys at the mouth of the Connecticut River, and near Milford and Stratford, on the north shore of Long Island Sound; also, from Lloyd's Neck eastward on the south shore, pp. 22, 23. Continuation of the topographical re-survey of the north shore of Long Island Sound in the vicinity of Madison, Guilford, and Branford, Conn., pp. 23, 24. Inshore hydrographic survey of the northern coast of Long Island Sound from Hammonasset Point to Welch's Point, p. 24. Six Mile Reef, p. 24. Northeast Reef, p. 25. Tidal observations with an automatic tide-gauge at the Light-House on the New Haven Breakwater, p. 25. Continuation of the topographic re-survey of the north shore of Long Island Sound westward from Frost (or Farms) Point, and including the Norwalk Islands; also topographical re-survey of the shores of East River, New York, pp. 25, 26. Triangulation in the western part of Long Island Sound extended from Lloyd's Neck towards New Rochelle, p. 26. Topographical re-survey of the north shore of Long Island Sound continued from Darien, Conn., towards New Rochelle, N. Y., p. 26. Topographical re-survey of the shores of the East River, New York, p. 26. Hydrographic re-survey of the East River, New York, pp. 26, 27. Determination of points for the re-survey of New York Lower Bay, p. 27. Hydrographic re-survey of the entrance to New York Bay, p. 27. Topographic re-survey of the shore lines of Coney Island and Rockaway Beach, New York Lower Bay, pp. 27, 28. Topographic re-survey of the shores of the North River, New York, p. 28. Hydrographic re-survey of the North River, New York, p. 28. Development of plans for the study of the physical hydrography of New York Bay and Harbor. Need of special examinations to ascertain the physical

## SECTION II.—Continued.

history of the changes in Monomoy Shoals, pp. 28, 29. Monomoy Shoals, p. 29. Mississippi River Commission, p. 29. Advisory Commissions, pp. 29, 30. Records of observations with self-registering tide-gauges at Governor's Island and at Sandy Hook, p. 30. Topographical re-survey of Sandy Hook, New Jersey, p. 30. Extension of reconnaissance and triangulation in the southern part of the State of New Jersey, pp. 30, 31. Extension of reconnaissance and triangulation in the eastern portion of the State of Pennsylvania, p. 31. Reconnaissance for triangulation in the western half of the State of Pennsylvania, p. 32. Special triangulation for the city of Philadelphia, p. 32. Physical hydrography of Delaware River and Bay, pp. 32-34. Special triangulation, Delaware River from Petty's Island to Poquessink Creek, p. 34. Magnetic observations at Philadelphia, pp. 34, 35. Determination of the position of a wreck off Barnegat, p. 35. Continuation of triangulation and reconnaissance on the New Jersey coast. Magnetic station occupied on that coast, and topographic survey continued, p. 35. Topographical re-survey of the New Jersey shore of Delaware Bay continued, pp. 35, 36. Completion of the topographical re-survey of the western shore of Delaware Bay, p. 36. Continuation of the hydrographic re-survey of Delaware Bay and entrance, pp. 36, 37.

## SECTION III.—Gravity determinations and experimental researches at Washington, D. C., and in Virginia, pp. 37, 38.

Annual determination of the magnetic declination, dip, and intensity at the station on Capitol Hill, Washington, p. 38. Continuation of the detailed topographical survey of the District of Columbia, pp. 38, 39. Lines of leveling of precision carried from Ashland, Va., to Fortress Monroe; also a line to connect the bench-mark near the Washington Aqueduct Bridge with the Capitol bench-mark, pp. 39, 40. Determination of points on the boundary line between Maryland and Virginia, pp. 40, 41. Hydrographic examinations off Cape Henry, Virginia, p. 41. Supplementary topographical survey between Norfolk and the ocean shore, p. 41. Extension of the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio, pp. 41, 42.

## SECTION V.—Hydrographic survey in the Stone and Wadmelow Rivers, South Carolina, pp. 42, 43.

## SECTION VI.—Triangulation and shore-line topography of Saint John's River, from Nine-Mile Point to Palatka, p. 43.

Hydrographic survey of Saint John's River, from Racy Point to Palatka, pp. 43, 44. Deep-sea soundings in Northwest Providence Channel and in the Gulf Stream off Florida coast, and subcurrent observations in the Gulf Stream, between Fowey Rocks and Gnn Cay, Bahamas, pp. 44-46. Determination of gravity at Key West, p. 46. Beach measure and topography on the west coast of Florida, from Bowditch Point to Cape Romano, pp. 46, 47. Hydrographic survey of the west coast of Florida, from the vicinity of Gordon's Pass to Cape Romano, p. 47.

## SECTION VIII.—Continuation of reconnaissance for the connection of the triangulation of the Gulf coast with that along the Blue Ridge, p. 48. Hydrographic work in Mobile Bay and around the Chandeleur Islands, pp. 48, 49. Determination of the longitudes of Little Rock, Texarkana, and Fort Smith, Ark., pp. 49, 50. Triangulation and topography of the coast of Louisiana, from Coté Blanche Bay to the westward, p. 50. Hydrographic survey off the coast of Louisiana from Sabine Pass eastward, pp. 50, 51.

## SECTION IX.—Determination of the longitude of Brownsville, Tex., p. 51. Triangulation and wire measurement between Point Isabel and Brownsville, Tex., pp. 51, 52.

## SECTION X.—Survey of the coast line connecting the work at San Juan Capistrano with that at Newport Bay, California, p. 52. Series of observations continued at the magnetic self-registering record station at Los Angeles, Cal., pp. 52, 53. Continuation of the primary triangulation of the coast of California north of Point Concepcion, pp. 53, 54. Survey of the coast of California continued from Moro Bay westward, p. 54. Hydrographic survey of the California coast in the vicinity of San Simeon, pp. 54, 55. Occupation of stations in continuation of the primary triangulation of the coast of California, pp. 55-57. Coast pilot work, p. 57. Magnetic observations, p. 57. Longitude of a station of the Hawaiian Government survey, p. 57. San Francisco sub-office, p. 57. Field catalogue of time and circumpolar stars, p. 57. Rocks in Mission Bay, p. 57. The bar of San Francisco, pp. 57, 58. Self-registering tide-gauge record kept up at Saucelito, San Francisco Bay, p. 58. Hydrographic surveys on the California coast in Humboldt Bay, and between Brushy Point and White Rock, pp. 58, 59.

## SECTION XI.—Triangulation and topography of the Umpquah River, Oregon, pp. 59, 60. Continuation of the topographical survey of the Columbia and Willamette Rivers. Hydrography of the Willamette River, pp. 60, 61. Completion of the topography of Hood's Canal, Washington Territory. Reconnaissance of the Olympic Mountains, p. 61. Hydrographic surveys in Hood's Canal, Washington Territory, pp. 61, 62. Triangulation and topography of Possession Strait and Sound, Washington Territory, p. 62. Reconnaissance for the triangulation of the Strait of Fuca, pp. 62-64. Hydrographic survey of the Strait of Fuca, pp. 64, 65.

## SECTION XII.—Hydrographic surveys in Southeastern Alaska, pp. 65, 66. Tidal observations continued with self-registering tide-gauge at Saint Paul, Kodiak Island, Alaska, p. 66.

## SECTION XIII.—Reconnaissance for extending the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio, p. 66. Occupation of station in continuation of the triangulation of the State of Tennessee, pp. 66, 67.

## ABSTRACT OF CONTENTS OF REPORT.

vii

**SECTION XIV.**—Reconnaissance for extending the primary triangulation near the thirty-ninth parallel into Ohio and Kentucky, p. 67. Continuation of the triangulation of the State of Ohio, p. 67. Occupation of stations in continuation of the triangulation of the State of Indiana, pp. 67, 68. Extension of the primary triangulation near the thirty-ninth parallel eastward across the State of Illinois, p. 68. Progress made in connecting the line of transcontinental leveling with a point on the Gulf coast, pp. 68, 69. Occupation of stations in continuation of the triangulation of the State of Wisconsin, p. 69.

**SECTION XV.**—Occupation of stations for continuing to the westward the primary triangulation in Missouri and Kansas, pp. 69, 70. Determination of the longitude of Kansas City, Mo., p. 70.

**SECTION XVI.**—Continuation of reconnaissance and triangulation in Utah near the thirty-ninth parallel, pp. 70, 71.

**SPECIAL OPERATIONS.**—Examination of methods of observation and photographic processes employed at the Magnetic Observatory, Toronto, Canada, pp. 71, 72. Reports in regard to sub-offices at Boston, New York, and Philadelphia. Sub-office at Boston, p. 72; sub-office at New York, p. 72; sub-office at Philadelphia, pp. 72, 73. Charge of the exhibit of the Coast and Geodetic Survey at the New Orleans Exposition, pp. 73, 74. Voyage of the new steamer C. P. Patterson from the Atlantic to the Pacific Coast, pp. 74, 75. Tidal observations at Honolulu, Sandwich Islands, p. 75.

**COAST AND GEODETIC SURVEY OFFICE.**—Assistant in charge and officers on duty, pp. 75–77; see also Appendices 1 to 5.

**PART III.**—Appendices to the report, Nos. 1–18, pp. 79–513.

## TITLES OF APPENDICES.

---

	Pagea.
No. 1. DISTRIBUTION OF THE PARTIES of the Coast and Geodetic Survey upon the Atlantic, Gulf of Mexico, and Pacific coasts, and in the interior of the United States during the fiscal year ending with June, 1885 .....	81-86
No. 2. STATISTICS of field and office work of the Coast and Geodetic Survey for the year ending June 30, 1885 .....	87-88
No. 3. INFORMATION furnished to Departments of the Government in reply to special requests, and to individuals upon application, during the fiscal year ending June 30, 1885 .....	89-93
No. 4. REPORT OF THE ASSISTANT IN CHARGE of office and topography for the year ending June 30, 1885.	95-116
No. 5. REPORT OF THE HYDROGRAPHIC INSPECTOR for the year ending June 30, 1885 .....	117-128
No. 6. THE GEOGRAPHICAL DISTRIBUTION and secular variation of the magnetic dip and intensity in the United States .....	129-274
No. 7. COLLECTION OF SOME MAGNETIC VARIATIONS off the coasts of California and Mexico, observed by Spanish navigators in the last quarter of the eighteenth century .....	275-284
No. 8. GEOGRAPHICAL POSITIONS OF TRIGONOMETRICAL POINTS in the States of Massachusetts and Rhode Island, determined by the United States Coast and Geodetic Survey between the years 1835 and 1885, and including those determined by the Borden Survey in the years 1832 to 1838 .....	285-439
No. 9. RESULTS deduced from the geodetic connection of the Yolo base-line with the primary triangulation of California. Also a reduction and adjustment of the Davidson quadrilaterals forming part of that triangulation .....	441-467
No. 10. ON GEODETIC RECONNAISSANCE .....	469-481
No. 11. A PLEA FOR A LIGHT on Saint George's Bank .....	483-485
No. 12. COMPARISON OF TRANSVERSE SECTIONS in the Delaware River, between old Navy-yard and east end of Petty's Island, for the years 1819, 1843, and 1878 .....	487-488
No. 13. ON THE HARMONIC ANALYSIS of the tides at Governor's Island, New York Harbor .....	489-493
No. 14. REPORT ON DEEP-SEA CURRENT WORK in the Gulf Stream .....	495-501
No. 15. NOTE on a device for abbreviating time reductions .....	503-508
No. 16. ON THE INFLUENCE OF A NODDY on the period of a pendulum .....	509-510
No. 17. ON THE EFFECT of unequal temperature upon a reversible pendulum .....	511-512
No. 18. TRIBUTE TO THE MEMORY OF HENRY W. BLAIR, assistant .....	513

# ALPHABETICAL INDEX.

## A.

ABSECON INLET, N. J., p. 35.  
 ABSTRACTS OF LOCALITIES OF WORK AND OF REPORTS OF OPERATIONS ON ATLANTIC, GULF, AND PACIFIC COASTS, AND IN INTERIOR, pp. 14-71.  
 ADDISON, ME., pp. 15, 16.  
 ADJUSTMENT AND REDUCTION OF THE DAVIDSON QUADRILATERALS, p. 6; Appendix No. 9, pp. 441-467.  
 ADMIRALTY INLET, POSSESSION SOUND, WASH. TER., p. 62.  
 ADVISORY COMMISSION (U. S.) ON IMPROVEMENT OF NAVIGATION OF THE DELAWARE, p. 7.  
 ADVISORY COMMISSIONS. The duties of, pp. 29, 30.  
 AID TO STATE SURVEYS, FURNISHING POINTS. Reference to, p. 2; for State of Massachusetts, p. 18; reference to in explanation of estimates, p. 8; in estimates, p. 11.  
 ALABAMA. Reconnaissance for connecting the triangulation of the Gulf coast with that along the Blue Ridge, p. 48; hydrographic work in Mobile Bay, pp. 48, 49.  
 ALAMO (steamer). Assistance rendered by Lieut. J. E. Pillsbury, p. 46.  
 ALASKA. Hydrographic surveys in, pp. 65, 66; Appendix No. 5, p. 121; hydrographic characteristics of, p. 65; magnetic observations at Karta Bay, p. 66; tidal observations at Saint Paul, Kadiak Island, p. 66; earthquake waves recorded at tidal station, p. 75; reference to, in estimates, p. 10; see also Appendix No. 4, pp. 96, 102.  
 ALBINA, OREG., p. 60.  
 ALEXANDER, PROF. W. D., SUPERINTENDENT OF THE HAWAIIAN GOVERNMENT SURVEY, pp. 57, 75, 86.  
 AMERICAN METROLOGICAL SOCIETY. Reference to memoir read by Assistant C. S. Peirce at meeting of, p. 38.  
 ANNUAL DETERMINATION OF THE MAGNETIC DECLINATION, DIP, AND INTENSITY AT THE STATION ON CAPITOL HILL, WASHINGTON, D. C., pp. 3, 38; Appendix No. 4, p. 99.  
 A PLEA FOR A LIGHT ON SAINT GEORGE'S BANK. Appendix No. 11, pp. 483-485; mention of, p. 7.  
 APPENDICES Nos. 1 to 18. For titles of, see page preceding Alphabetical Index.  
 APPENDICES—No. 1, pp. 81-86; No. 2, pp. 87, 88; No. 3, pp. 89-93; No. 4, pp. 95-116; No. 5, pp. 117-128; No. 6, pp. 129-274; No. 7, pp. 275-284; No. 8, pp. 285-439; No. 9, pp. 441-467; No. 10, pp. 469-481; No. 11, pp. 483-485; No. 12, pp. 487-488; No. 13, pp. 489-493; No. 14, pp. 495-501; No. 15, pp. 503-508; No. 16, pp. 509-510; No. 17, pp. 511, 512; No. 18, p. 513.  
 APPENDIX—No. 1, reference to, pp. 2, 14; Nos. 2, 3, reference to, p. 76; No. 4, pp. 14, 76; No. 5, p. 14; Nos. 6, 8, 9, p. 6; No. 11, p. 7; No. 12, pp. 7, 33; No. 13, p. 7; No. 14, p. 44; No. 18, p. 76; No. 11, of 1878, pp. 7, 17; No. 10, of 1879, p. 17; Nos. 12, 13, 17, of 1882, p. 7; No. 8, of 1883, p. 33; No. 9, of 1883, p. 7; No. 18, of 1883, p. 57; No. 15, of 1884, p. 37; No. 17, of 1884, pp. 73-74.  
 APPLEPIE HILL STATION, N. J., p. 30.  
 APPROPRIATIONS REQUIRED FOR THE WORK OF THE COAST AND GEODETIC SURVEY DURING FISCAL YEAR 1886-'87, pp. 8-13.  
 ARAGO (steamer). Use of in Section V, p. 42; in Section VI, p. 43; see Appendix No. 5, p. 119.

ARCHIVES AND LIBRARY. In charge of R. M. Harvey, Appendix No. 4, p. 97; report of T. D. Reed, custodian, Appendix No. 4, pp. 112-114.  
 AREAS OF SALT AND FRESH MARSH LAND ON ATLANTIC AND GULF COASTS, p. 76; Appendix No. 4, p. 97.  
 ARKANSAS. Determinations of longitude at stations in, pp. 49, 50.  
 ASCUTNEY MOUNTAIN, VT., p. 18.  
 ASHBURNER, DR. CHARLES, STATE GEOLOGIST OF PENNSYLVANIA, p. 32.  
 ASHLAND, VA. Lines of levelling from, to Fortress Monroe, pp. 39, 40.  
 ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR YEAR ENDING JUNE 30, 1885. Assistant C. O. Bontelle, report from, Appendix No. 4, pp. 95-116; relative to the report, p. 75.  
 ASSISTANTS IN CHARGE OF COAST AND GEODETIC SURVEY EXHIBIT AT THE NEW ORLEANS EXPOSITION, pp. 73, 74; Appendix No. 4, p. 97.  
 ASTRONOMICAL WORK, STATISTICS OF. Appendix No. 2, p. 87; Appendix No. 4, p. 113.  
 A TRIBUTE TO THE MEMORY OF H. W. BLAIR, ASSISTANT. Appendix No. 13, p. 513.  
 ATKINS, J. W. G., AID. Services in Section II, p. 23.  
 ATLANTA, GA. Reference to, in estimates, p. 10.  
 ATLANTIC COAST. Progress of work on, pp. 2-4; reference to, in estimates, pp. 9-13.  
 ATLANTIC COAST. Section I, pp. 14-21; Section II, pp. 21-37; Section III, pp. 37-42; Section V, pp. 42, 43; Section VI, pp. 43, 47.  
 ATLANTIC AND GULF COASTS. Reference to, in estimates, p. 10; measurement of areas of salt and fresh marsh land on, p. 76; Appendix No. 4, p. 97.  
 ATLANTIC AND PACIFIC COASTS. Progress of triangulation connecting, p. 2; field work in, localities between, p. 4; estimates for work on, pp. 9-13; lines of levelling between, reference to, in estimates, p. 10; transfer of steamer C. P. Patterson from to, pp. 4, 74, 75; Appendix No. 5, p. 121.  
 AUHAGEN, W. Computing Division, Coast and Geodetic Survey Office, Appendix No. 4, pp. 99, 101.  
 AVERY, R. S. In charge Tidal Division, Coast and Geodetic Survey Office. Reference to, Appendix No. 4, p. 96; report of, pp. 101-103.  
 AVERY, Mr. Proprietor of Petit Anse Island. Acknowledgment of obligations to, p. 50.  
 AYDELOTT, WILLIAM J., BOUNDARY COMMISSIONER OF MARYLAND, p. 40.  
 AYRES, S. C. Appendix No. 4, pp. 97, 99, 101.

## B.

BACHE, A. D. (steamer). Use of, in Section VI, p. 47; in Section VIII, pp. 48, 49; see Appendix No. 5, p. 118.  
 BACHE, CHARLES M., ASSISTANT. Triangulation from Townsend's Inlet to Absecon Light, Atlantic City, N. J., p. 35; Appendix No. 1, p. 83.  
 BACHE, G. M. (schooner). Appendix No. 5, p. 120.  
 BACHE, R. M., ASSISTANT. Topographical resurvey of the New Jersey shore of Delaware Bay, pp. 85, 86; Appendix No. 1, p. 83.  
 BACON, F. B., RECORDER. Appendix No. 1, p. 86.



- BAGWELL, GEORGE H., BOUNDARY COMMISSIONER OF VIRGINIA, p. 40.
- BAKER, MARCUS, ASSISTANT. Hydrological survey of New York Bay and Harbor, pp. 28, 29, 76; magnetic observations at Los Angeles, Cal., pp. 52, 53; special magnetic duty at Toronto, Canada, pp. 53, 71, 72; magnetic observations at Kalamazoo, Mich., p. 72; tidal investigations, p. 76; preparation of Alaska coast pilots' charts, &c., p. 76; see Appendix 1, pp. 82, 84, 86.
- BAIDLEGE, N. H., p. 18.
- BARATARIA (steamer). Appendix No. 5, p. 120.
- BARBOUR, PROF. V. G., ACTING ASSISTANT. Geodetic operations in Vermont, p. 18; Appendix 1, p. 81.
- BAR HARBOR. Resurvey of, pp. 16, 17.
- BARKER, J. H. Miscellaneous Division Coast, and Geodetic Survey Office, Appendix No. 4, p. 105.
- BARNARD, PROF. L. H., ACTING ASSISTANT. Reconnaissance in Pennsylvania, p. 32; Appendix 1, p. 83.
- BARNEGAT, N. J. Location of wreck off, p. 35.
- BARR, J. C. Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 105.
- BARTON STATION, HOCKING COUNTY, OHIO.
- BASE LINES. Statistics of, Appendix No. 2, p. 87.
- BASSETT, R. T. Miscellaneous Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 111.
- BASS POINT, NAHANT, MASS. Hydrographic examinations near, p. 17; directions for avoiding rock near, pp. 5, 17.
- BATTERY O'BRIEN, FORT POINT, ME., p. 15.
- BAYLOR, J. B., SUB-ASSISTANT. Magnetic observations in Section I, pp. 20, 21; service in Section II, p. 35; see Appendix 1, pp. 81, 83; Appendix No. 4, p. 97.
- BAY OF NORTH AMERICA. Reference to the model of the depths of the sea in, pp. 73-74.
- BEACH MEASUREMENT AND TOPOGRAPHICAL SURVEY ON THE WEST COAST OF FLORIDA, FROM BOWDITCH POINT TO CAPE ROMANO, pp. 46, 47.
- BEAUTY (barge). Laid up at Sea Isle City, p. 35; use of in Section II, Appendix No. 5, p. 120.
- BECHER BAY, STRAIT OF FUCA, p. 63.
- BEDFORD REEF, p. 20.
- BELL, J. A., ENSIGN, U. S. N. Services in Section X, p. 59; Appendix No. 1, p. 85.
- BELLE AIR STATION, ILL., p. 68.
- BELLEVUE HOTEL STATION, RED BANK, N. J. p. 32.
- BERLIN, N. J., p. 30.
- BERRY STATION, CASS COUNTY, MO., p. 70.
- BIBB, P. R., ENSIGN, U. S. N. Services in Section X, p. 55; Appendix No. 1, p. 85.
- BIEN, JULIUS & CO. Reference to lithography done by, p. 28.
- BIG CARLOS INLET, FLA., p. 47.
- BIG MARCO INLET, FLA., p. 47.
- BIRD, GEO. F., AID. Services in Section VIII, p. 48; in Section XVI, p. 71; see Appendix No. 1, pp. 84, 86.
- BITLER, R. O., ENSIGN, U. S. N. Services in Section II, p. 27.
- BLAIR, HENRY W., ASSISTANT. Preparation of Coast and Geodetic Survey Exhibit for New Orleans Exposition, p. 73; death at Nashville, Tenn., p. 73; see also p. 76, Appendix No. 4, pp. 97, 98, and Appendix No. 18, p. 513.
- BLAKE (steamer). Use of in Section 1, pp. 19, 20; in Section VI, p. 44; see also Appendix No. 5, pp. 117, 119.
- BLIND ASYLUM STATION, IND., p. 67.
- BLOCK ISLAND SOUND. Hydrographic examinations in, pp. 3, 19, 20.
- BLOCKLINGER, G., LIEUTENANT, U. S. N. Services in Section XI, p. 65; Appendix No. 1, p. 85.
- BLUE RIDGE. Reference to, in estimates, p. 10; reconnaissance in, p. 48.
- BOARD OF PORT WARDENS OF PHILADELPHIA. Information furnished to, p. 73.
- BOARD OF TRADE OF PHILADELPHIA. Information furnished, p. 73.
- BORDEN SURVEY OF MASSACHUSETTS. Reference to, pp. 6, 19; recomputation and adjustment of, Appendix No. 4, p. 99.
- BORDEN, T. P., AID. Services in Section XI, pp. 63, 64.
- BOSCHKE'S MAP OF THE DISTRICT OF COLUMBIA. Reference to, p. 38.
- BOSTON, MASS. Sub-office at, pp. 4, 72.
- BOSTWICK, F. M., ENSIGN, U. S. N. Services in Section XI, p. 65; Appendix 1, p. 85.
- BOUNDARY LINE BETWEEN MARYLAND AND VIRGINIA. Determination of points on, pp. 40, 41.
- BOUTELLE, CHARLES O., ASSISTANT. In charge of Coast and Geodetic Survey Office, pp. 14-75; preparation of projection tables, reference to, p. 14; Appendix No. 4, p. 97; general supervision of preparation of Coast and Geodetic Survey Exhibit for the New Orleans Exposition, p. 73; reference to report of, pp. 75, 76; report of, Appendix No. 4, pp. 95-98.
- BOUTELLE, J. B., EXTRA OBSERVER. Services in Section XIV, p. 68; see Appendix No. 1, p. 86; Appendix No. 4, pp. 99, 101.
- BOWDITCH POINT, FLA., pp. 46, 47.
- BOWLER STATION, JACKSON COUNTY, MO., p. 70.
- BOWSER, PROF. E. A., ACTING ASSISTANT. Geodetic operations in New Jersey, pp. 30, 31; Appendix No. 1, p. 82.
- BOYD, C. H., ASSISTANT. Topographical survey on coast of Maine, pp. 14, 15; in charge of Coast and Geodetic Survey Exhibit at New Orleans, pp. 15, 74; see Appendix No. 1, pp. 81, 86.
- BRADFORD, GERSHOM, ASSISTANT. Triangulation in Massachusetts, pp. 18, 19; reconnaissance and triangulation in Long Island Sound, p. 26; Appendix No. 1, pp. 81, 82, 86.
- BRADFORD, J. S., ASSISTANT. Primary triangulation in Illinois, p. 68; Appendix No. 1, p. 86.
- BRAID, ANDREW, ASSISTANT. Suggestions relative to photographic processes, p. 72; report of the work done in the Instrument Division of the Coast and Geodetic Survey Office, Appendix No. 4, pp. 114-115.
- BRAINARD, F. R., ENSIGN, U. S. N. Services in Section I, p. 21; in Section II, pp. 22, 27; in Section V, p. 43; in Section VII, p. 44; see also Appendix No. 1, pp. 81, 82, 83, 84.
- BRANFORD, CONN. Topographical re-survey in vicinity of, pp. 23, 24; desirability of harbor of, p. 25.
- BRANFORD REEF, p. 25.
- BRIDGEPORT HARBOR, CONN., p. 23.
- BRIGHT, W. T. In charge Drawing Division, Coast and Geodetic Survey Office, reference to, p. 96; report of, Appendix No. 4, pp. 103-105.
- BROADKILL CREEK, DELAWARE BAY, p. 36.
- BROAD TOP, PA., p. 32.
- BRONAUGH, W. V., ENSIGN, U. S. N. Services in Section XI, p. 65; Appendix No. 1, p. 85.
- BROOKLYN BRIDGE, p. 26.
- BROWN, CHARLES E. Miscellaneous Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 111.
- BROWNSON, W. H., LIEUTENANT-COMMANDER, U. S. N. Hydrographic examinations in Vineyard Sound, Narragansett Bay, and Block Island Sound, pp. 19, 20; determination of position of wreck off Barnegat, p. 35; see Appendix No. 1, pp. 81, 83; Appendix No. 5, p. 117; reference to appointment as Hydrographic Inspector, Appendix No. 5, p. 119.
- BROWNSVILLE, TEXAS. Triangulation and wire measurement between Point Isabel and, pp. 4, 51, 52; determination of longitude at, p. 51.
- BRUMBY, T. M., ENSIGN, U. S. N. Services in Section VII, p. 51; Appendix No. 1, p. 84.
- BRUSHY POINT, HUMBOLDT BAY, CAL. Hydrographic survey between White Rock and, pp. 58, 59.
- BUCHANAN, PROF. A. H., ACTING ASSISTANT. Geodetic operations in Tennessee, pp. 66, 67; Appendix No. 1, p. 85.
- BUENA VISTA STATION, BUENA VISTA COUNTY, KY., pp. 41, 42.
- BURDICK, W. L., ENSIGN, U. S. N. Services in Section X, pp. 55, 58, 59; Appendix No. 1, p. 85.

## C.

- CABIN STATION, WASH. TER., p. 61.
- CALCASIEU RIVER, TEX., Appendix No. 5, p. 119.
- CALCASIEU LAKE, TEX., Appendix No. 5, p. 119.

- CALIFORNIA.** Reference to, in estimates, p. 10; survey of coast line between San Juan, Capistrano, and Newport Bay, p. 52; survey of coast from Moro Bay westward, p. 54; primary triangulation of the coast of, pp. 53, 54, 55, 56; magnetic observations in, pp. 52, 53, 57; hydrographic survey in the vicinity of San Simeon, pp. 54, 55; between Brushy Point and White Rock, pp. 58, 59; Coast Pilot work, p. 57; connection of Coast and Geodetic Survey station with station of the Hawaiian Government Survey, pp. 57, 75; rocks in Mission Bay, p. 57; the Bar of San Francisco, pp. 55, 57, 58; tidal observations at Sancelito, pp. 58, 75; see also Appendix No. 1, pp. 84, 85; Appendix No. 4, pp. 96, 102; Appendix No. 5, p. 121.
- CANFIELD, W. C., ENSIGN, U. S. N.** Services in Section I, p. 16; in Section VI, p. 47; in Section VIII, p. 49; see Appendix 1, pp. 81, 84.
- CANONICUT ISLAND,** p. 20.
- CAPE COD, MASS.,** changes in coast line, p. 29.
- CAPE CANAVERAL,** lines of soundings near, p. 44.
- CAPE FLORIDA,** lines of soundings near, p. 44.
- CAPE HENRY, VA.** Special examinations of, p. 2, 41; Appendix No. 5, p. 118.
- CAPE HENLOPEN,** p. 36.
- CAPE MAY,** p. 36.
- CAPE MENDOCINO, CAL.,** p. 58.
- CAPE ROMANO, FLA.** Beach measure and topographical survey from Bowditch Point to, pp. 46, 47; hydrographic survey from Gordon's Pass to, p. 47.
- CAPE SABLE, FLA.,** p. 46.
- CAPITOL BENCH-MARK.** Line of levels run between Washington Aqueduct Bridge and, pp. 39, 40.
- CAPITOL HILL OBSERVATORY.** Annual magnetic observations at, pp. 34, 38.
- CAPTAIN'S ISLAND, OAK NECK, LONG ISLAND SOUND,** p. 28.
- CARPMAN, CHARLES, DIRECTOR MAGNETIC OBSERVATORY, TORONTO, CANADA,** p. 71.
- CARTER, F. S., LIEUTENANT, U. S. N.** Hydrological survey of New York Bay and Harbor, p. 28; Appendix No. 5, p. 120.
- CASE'S INLET, HOOD'S CANAL, WASH. TER.,** p. 61.
- CASTLE MOUNTAIN, CAL.,** p. 54.
- CASTLE POINT, N. Y.,** p. 28.
- CASTLE WILLIAM, GOVERNOR'S ISLAND, NEW YORK HARBOR,** p. 26.
- CAVITT, N. Y.** Miscellaneous Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 111.
- CAVEN'S POINT, N. Y.,** p. 28.
- CAXIMBAS PASS, FLA.,** p. 46.
- CAYUCOS, ESTERO BAY, CAL.,** p. 54.
- CEDAR POINT, LONG ISLAND SOUND,** pp. 24, 28.
- CHAMBER OF COMMERCE, NEW YORK CITY,** p. 72.
- CHANDELEUR ISLANDS.** Hydrographic survey near, p. 49; Appendix No. 5, p. 118.
- CHANDLER'S BAY, ME.** Topographical survey of, p. 15.
- CHAPMAN, D. C.** Office of Construction of Standard Weights and Measures, Appendix No. 4, pp. 115, 116.
- CHARGE OF THE EXHIBIT OF THE COAST AND GEODETIC SURVEY AT THE NEW ORLEANS EXPOSITION,** pp. 73, 74.
- CHARLESTON, S. C.** Reference to, in estimates, p. 10; tidal observations at, Appendix No. 4, p. 101.
- CHARTS.** New charts published, p. 5; number of copies distributed, p. 5; Appendix No. 4, pp. 111, 112; number received in chart room, Appendix No. 4, pp. 111, 112; completed or in progress during the year ending June 30, 1885, Appendix No. 4, pp. 105, 106.
- CHARTS FOR WHICH REDUCED DRAWINGS OF HYDROGRAPHY WERE MADE DURING THE FISCAL YEAR ENDING JUNE 30, 1885,** Appendix No. 5, p. 125.
- CHART PLATES.** Number completed, p. 5; corrected, pp. 4, 5; Appendix 4, pp. 95, 107, 108-110.
- CHATHAM, MASS.,** p. 29.
- CHERRYFIELD, ME.,** pp. 15, 16.
- CHERRY RIDGE, KY.,** p. 42.
- CHESAPEAKE BAY.** Estuaries of, reference to, in estimates, p. 10.
- CHESTER, C. M., COMMANDER, U. S. N., HYDROGRAPHIC INSPECTOR, COAST AND GEODETIC SURVEY.** Reference to services of, p. 14; reference to report on the sea-going qualities of steamer Patterson, p. 74; examinations in Ship and Swash channels, Appendix No. 5, p. 118; report of, Appendix No. 5, pp. 117-128.
- CHILTON, W. B.** Clerk in office Superintendent Coast and Geodetic Survey, p. 76.
- CHOCTAW BLUFF, ALA.,** p. 48.
- CHRISTIE, A. S.** Computing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 100.
- CLAREMONT STATION, ILL.,** p. 68.
- CLARENCE STRAIT, SOUTHEASTERN ALASKA,** p. 65.
- CLARK, JOHN.** Instrument Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 115.
- CLARK, DR. JAS. J.** In charge of Weights and Measures Exhibit at the New Orleans Exposition, p. 74; adjuster of weights and measures, Appendix No. 4, pp. 97, 115; report of Office of Construction of Standard Weights and Measures, Appendix No. 4, pp. 115, 116; see also Appendix No. 1, p. 86.
- CLARK'S POINT STATION,** p. 36.
- CLARVOE, G. W.** Miscellaneous Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 111.
- CLINTON, CONN.,** pp. 5, 23, 24.
- CLOVER, RICHARDSON, LIEUTENANT, U. S. N., HYDROGRAPHIC SURVEYS IN SOUTHEASTERN ALASKA,** pp. 65, 66, 75; reference to report on the voyage of the steamer Patterson to the Pacific coast, pp. 74, 75; Appendix No. 1, pp. 85, 86; Appendix No. 5, p. 121.
- COAL-BIN SHOAL, FLA.,** p. 47.
- COAST AND GEODETIC SURVEY.** Remarks on progress and condition of, pp. 1-4; abstracts of progress of work, pp. 15-77; officers of, and office work, pp. 75-77; see also Appendix No. 1, pp. 81-86; Appendix No. 4, pp. 95-116; Appendix No. 5, pp. 117-128; estimates for field and office work, pp. 10-12; general estimate for repairs and maintenance of vessels, p. 13; statistics of field and office work for the year ending June 30, 1885, Appendix No. 2, pp. 87, 88; exhibit of the, at the New Orleans Exposition, pp. 4, 73, 74; Appendix No. 4, p. 97.
- COAST AND GEODETIC SURVEY OFFICE.** Progress of work in, pp. 4-7; officers and employees of, pp. 75-77; see also Appendices Nos. 1, 4, pp. 81-86, 95-116; estimate for pay of officers of, pp. 11, 12; information furnished from the, in reply to special calls during the year ending June 30, 1885, Appendix No. 3, pp. 89-93.
- COASTERS' HARBOR ISLAND, NARRAGANSETT BAY.** Magnetic observations at, p. 20.
- COAST AND GEODETIC EXHIBIT AT THE NEW ORLEANS EXPOSITION,** pp. 73, 74.
- COAST PILOT.** Estimates for, p. 10; valuable information for, furnished by Lieutenant Tausig, p. 55; views furnished for, by F. Westdahl, p. 57.
- COAST-PILOT DIVISION,** charge of, p. 14; Appendix No. 5, p. 122.
- CODMAN, EDWARD W.,** p. 17.
- COFFEE ISLAND, MOBILE BAY,** p. 49.
- COLLECTION OF MAGNETIC VARIATIONS OFF THE COASTS OF CALIFORNIA AND MEXICO, OBSERVED BY SPANISH NAVIGATORS IN THE LAST QUARTER OF THE EIGHTEENTH CENTURY.**
- COLONNA, B. A., ASSISTANT.** Reconnaissance for triangulation in the Strait of Fuca, pp. 62, 63; reference to reports of, pp. 63, 64; see Appendix No. 1, p. 85; Appendix No. 4, p. 98.
- COLUMBIA RIVER.** Topographical survey of, pp. 60, 61; reference to, in estimates, p. 10.
- COMMISSIONER OF AGRICULTURE.** Information furnished to, p. 76.
- COMPARISON OF TRANSVERSE SECTIONS OF THE DELAWARE RIVER BETWEEN OLD NAVY-YARD AND EAST END OF PETTY'S ISLAND, AS DERIVED FROM THE SURVEYS OF 1819, 1843, AND 1878,** pp. 7, 33; Appendix No. 12, pp. 487-488.
- COMPLETION OF THE TOPOGRAPHICAL RESURVEY OF THE WESTERN SHORE OF DELAWARE BAY,** p. 36.
- COMPLETION OF THE TOPOGRAPHY OF HOOD'S CANAL, WASH. TER.** Reconnaissance of the Olympic Mountains, p. 61.

- COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE. Reference to, Appendix No. 4, p. 95; report from, Appendix No. 4, pp. 99-101.
- CONEY ISLAND. Topographical re-survey of shore line of, p. 27.
- CONNECTICUT. Topographic re-surveys of Stonington and vicinity, and of the coast in the vicinity of Saybrook and Lyme, p. 25; tidal observations at Fort Trumbull, p. 26; topographic re-survey of shore between New London and Four Mile River, and between Saybrook and Clinton, p. 28; and between Bridgeport and Farms (or Frost) Point, p. 30.
- CONNECTICUT RIVER. Topographical survey at mouth of, p. 22.
- CONNECTIONS BETWEEN THE COAST AND GEODETIC SURVEY TRIANGULATION AND THAT OF THE U. S. LAKE SURVEY, pp. 68-69.
- CONSTELLATION ROCK, GARDINER'S BAY, LONG ISLAND, p. 20.
- CONTINUATION OF THE TRIANGULATION OF THE STATE OF NEW HAMPSHIRE, pp. 17, 18.
- CONTINUATION OF THE TOPOGRAPHICAL RE-SURVEY OF THE NORTH SHORE OF LONG ISLAND TO THE WEST OF GREENPORT, p. 22.
- CONTINUATION OF THE TOPOGRAPHICAL RE-SURVEY OF THE NORTH SHORE OF LONG ISLAND SOUND IN THE VICINITY OF MADISON, GUILFORD, AND BRANFORD, CONN., pp. 23, 24.
- CONTINUATION OF THE TOPOGRAPHIC RE-SURVEY OF THE NORTH SHORE OF LONG ISLAND SOUND WESTWARD FROM FROST (OR FARMS) POINT, AND INCLUDING THE NORWALK ISLANDS; ALSO TOPOGRAPHICAL RE-SURVEY OF THE SHORES OF EAST RIVER, N. Y., pp. 25, 26.
- CONTINUATION OF TRIANGULATION AND RECONNAISSANCE ON THE NEW JERSEY COAST. Magnetic station occupied on that coast, and topographic survey continued, p. 35.
- CONTINUATION OF THE HYDROGRAPHIC RE-SURVEY OF DELAWARE BAY AND ENTRANCE, pp. 36, 37.
- CONTINUATION OF THE DETAILED TOPOGRAPHICAL SURVEY OF THE DISTRICT OF COLUMBIA, pp. 38, 39.
- CONTINUATION OF RECONNAISSANCE FOR THE CONNECTION OF THE TRIANGULATION OF THE GULF COAST WITH THAT ALONG THE BLUE RIDGE, p. 48.
- CONTINUATION OF THE PRIMARY TRIANGULATION OF THE COAST OF CALIFORNIA, NORTH OF POINT CONCEPCION, pp. 53, 54.
- CONTINUATION OF THE TOPOGRAPHICAL SURVEY OF THE COLUMBIA AND WILLAMETTE RIVERS. Hydrography of the Willamette River, pp. 60, 61.
- CONTINUATION OF THE TRIANGULATION OF THE STATE OF OHIO, p. 67.
- CONTINUATION OF RECONNAISSANCE AND TRIANGULATION IN UTAH NEAR THE THIRTY-NINTH PARALLEL, p. 70, 71.
- COOS BAY, OREG., p. 60.
- CORBETT, J. W. Tidal observer at Sandy Hook, p. 30; Appendix No. 4, p. 102.
- CORNWALL, LIEUTENANT-GOVERNOR OF THE DOMINION GOVERNMENT AT VICTORIA, BRITISH COLUMBIA, pp. 62, 63.
- CORYDON STATION, N. H., p. 18.
- COSGROVE, P. L., p. 47.
- COTÉ BLANCHE BAY, LA., TRIANGULATION FROM, TO THE WESTWARD, p. 50.
- COTTON STATION, VT., p. 18.
- COULTER, PROF. J. N., p. 68; Appendix No. 1, p. 86.
- COURTENAY, E. H. Computing Division Coast and Geodetic Survey Office; Appendix No. 4, pp. 99, 100.
- COURTENAY, F. Engraving Division Coast and Geodetic Survey Office; Appendix No. 4, p. 107.
- COX, G. F. Miscellaneous Division Coast and Geodetic Survey Office, Appendix No. 4, p. 111.
- CRAVEN, J. E., ENSIGN, U. S. N. Services in Section VI, p. 47; in Section VIII, p. 49; Appendix No. 1, p. 84.
- CROOKS, MAJOR, p. 50.
- CROSBY, F. H., LIEUTENANT, U. S. N. Hydrographic survey off the coast of Louisiana from Sabine Pass to the eastward, pp. 50, 51; surveys in Sabine and Calcasieu Lakes, Tex., Appendix No. 5, p. 119; see Appendix No. 1, pp. 81, 84.
- CUBE MOUNTAIN, N. H., p. 18.
- CURRENTS OF THE GULF STREAM. Investigation of, pp. 2, 4, 44, 46; reference to, in estimates, pp. 9, 10; see Appendix No. 5, p. 119; also Appendix No. 14, pp. 493-501.
- CURRENT OBSERVATIONS IN DELAWARE BAY. Reference to, in estimates, p. 10.
- CUTLER, ME., p. 15.
- CUTLER, W. G., LIEUTENANT, U. S. N. Hydrographic survey of the north coast of Long Island Sound from Hammonasset to Welch's Point, pp. 24, 25; of North River and approaches, p. 68; see also Appendix No. 1, p. 82; Appendix No. 5, pp. 118, 119, 120.

## D.

- DABOP BAY, HOOD'S CANAL, WASH., p. 61.
- DAISY (steamer). Use of in Section II, Appendix No. 5, p. 119; transferred to Coast and Geodetic Survey from Light-House Board, reference to, p. 120.
- DALL, WILLIAM H., ASSISTANT. Services in Coast and Geodetic Survey and resignation, p. 76.
- DANGERS TO NAVIGATION. Mention of, pp. 5, 17, 19, 20, 21, 24, 25, 47.
- DARIEN, CONN. Topographical re-survey near, pp. 21, 22, 26.
- DAVIDSON, GEORGE, ASSISTANT. In charge of work on the Pacific coast, pp. 55-58, and 66; Appendix No. 1, p. 85.
- DAVIDSON QUADRILATERALS. Adjustment and reduction of, p. 76; Appendix No. 9, pp. 441-467.
- DAVIES, PROF. JOHN E., ACTING ASSISTANT. Continuation of the triangulation of the State of Wisconsin, p. 69; Appendix No. 1, p. 86; Appendix No. 4, p. 107.
- DAVIS, W. H. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- DEADENING STATION, RHEA COUNTY, TENN., p. 66.
- DEAN, GEORGE W., ASSISTANT. In charge Coast and Geodetic Survey Exhibit at New Orleans Exposition, pp. 73, 74; Appendix No. 1, p. 86.
- DEEP CREEK, SAINT JOHN'S RIVER, FLA., p. 44.
- DEEP-SEA SOUNDINGS IN NORTHWEST PROVIDENCE CHANNEL, AND IN THE GULF STREAM OFF FLORIDA COAST, AND SUB-CURRENT OBSERVATIONS IN THE GULF STREAM BETWEEN FOWEY ROCKS AND GUN CAY, BAHAMAS, pp. 44-46.
- DEEP-SEA CURRENTS, pp. 4, 44. Appendix No. 5, p. 119; also No. 14, pp. 495-501.
- DELAFIELD STATION, WIS., p. 69.
- DELAWARE BAY. Reference to, in estimates, p. 10; changes in shoals, p. 30; topographic re-survey of shores of, pp. 35, 36; hydrographic re-survey of, pp. 36, 37.
- DELAWARE BAY AND RIVER. Reference to solution of practical questions respecting dividing line between, pp. 30 and 33; physical hydrography of, pp. 32-34.
- DELAWARE RIVER. Special triangulation from Petty's Island to Poquessink Creek, p. 34; examination of movements of ice in, p. 32; location of port-warden lines in, p. 33; settlement of question as to fishing rights of the States of Delaware and New Jersey, p. 33.
- DENIS, VICENTE, JANITOR, SUB-OFFICE, CAL., p. 57.
- DENNIS, W. H., ASSISTANT. Continuation of topographical survey in vicinity of Madison, Guilford, and Branford, Conn., pp. 23, 24; Appendix No. 1, p. 82.
- DEPARTMENT OF DOCKS, NEW YORK CITY, p. 26.
- DEPARTMENT OF SURVEYS OF BROOKLYN, N. Y., p. 26.
- DEPARTMENT OF SURVEY OF PHILADELPHIA, p. 73.
- DEPARTMENTS OF THE GOVERNMENT. Information furnished to, p. 4; Appendix No. 3, pp. 89-93; charts furnished to, p. 5; Appendix No. 4, p. 111.
- DESERET RAILROAD STATION, UTAH. Magnetic observations at, p. 71.
- DETERMINATION OF GRAVITY AT KEY WEST, FLA., p. 46.
- DETERMINATION OF LONGITUDE AT LITTLE ROCK, TEX., ARKANA, AND FORT SMITH, ARK., p. 49.

**DETERMINATION OF LONGITUDE OF BROWNSVILLE, TEX.**, p. 51; of Kansas City, Mo., p. 70.  
**DETERMINATION OF POINTS FOR THE RE-SURVEY OF NEW YORK LOWER BAY**, p. 27.  
**DETERMINATION OF POINTS ON THE BOUNDARY LINE BETWEEN MARYLAND AND VIRGINIA**, pp. 40, 41.  
**DETERMINATION OF POSITION OF WRECK OFF BARNEGAT**, p. 33.  
**DEVELOPMENT OF PLANS FOR THE STUDY OF THE PHYSICAL HYDROGRAPHY OF NEW YORK BAY AND HARBOR.** Need of special examinations to ascertain the physical history of the changes in Monomoy Shoals, p. 28.  
**DEVIL'S ELBOW, FLA.**, p. 43.  
**DEVOL, PROF. R. S., ACTING ASSISTANT.** Continuation of the triangulation of the State of Ohio, p. 67; Appendix No. 1, p. 86.  
**DEWEY, T. G., ENSIGN, U. S. N.** Services in Section XII, p. 66; Appendix No. 1, p. 85.  
**DICKINS, E. F., ASSISTANT.** Services in Section I, pp. 16, 17; determination of points for the re-survey of New York Lower Bay and Harbor, p. 27; Appendix No. 1, pp. 81, 82.  
**DIMOND REEF, EAST RIVER, N. Y.** Location of rock near, pp. 2, 5, 27.  
**DISCOVERIES AND DEVELOPMENTS**, p. 5.  
**DISTRICT OF COLUMBIA.** Gravity determinations and experimental researches at Washington, p. 37; annual determination of the magnetic declination, dip, and intensity at the magnetic station on Capitol Hill, Washington, p. 38; Boschke's map of, reference to, p. 38; Ellicott's map, reference to, p. 38; continuation of the detailed topographical survey of, pp. 38, 39.  
**DISTRIBUTION OF PARTIES OF THE COAST AND GEODETIC SURVEY UPON THE ATLANTIC, GULF OF MEXICO AND PACIFIC COASTS, AND IN THE INTERIOR OF THE UNITED STATES DURING THE FISCAL YEAR ENDING WITH JUNE, 1885.** Appendix No. 1, pp. 81-86.  
**DIVISION OF TIDES.** See Appendix No. 4, pp. 101-103.  
**DIXIE ISLAND, MOBILE BAY**, p. 49.  
**DIXON, W. S., PASSED ASSISTANT SURGEON, U. S. N.** Services in Section XI, p. 65.  
**DOCIWALAPO RIVER, WASH. TER.**, p. 61.  
**DODD, A. W., ENSIGN, U. S. A.** Services in Section II, p. 27.  
**DONN, F. C.** Draughtsman in Hydrographic Inspector's Office, p. 14; Appendix No. 5, p. 122.  
**DONN, J. W., ASSISTANT.** Continuation of the topographical survey of the District of Columbia, pp. 38, 39; Appendix No. 1, p. 83.  
**DOOLITTLE, MYRICK H.** Computing Division, Coast and Geodetic Survey Office, Appendix No. 4, pp. 97, 100.  
**DRAWING DIVISION.** Report from, Appendix No. 4, pp. 103-105; list of charts completed or in progress during the year ending June 30, 1885, Appendix No. 4, pp. 105, 106.  
**DRIFT (schooner).** Use of in Section II, p. 28; Appendix No. 5, pp. 118, 120.  
**DUANE, GENERAL.** Courtesies received from, p. 50.  
**DUCKABUSH RIVER, WASH. TER.**, p. 61.  
**DUCK ISLAND, LONG ISLAND SOUND**, p. 22.  
**DUDLEY, J. W., ACTING AID.** Services in Section II, p. 24; Appendix No. 1, p. 82.  
**DUNGENESS—DISCOVERY** line of triangulation, p. 63.  
**DU PUY, A. L.** Services at magnetic observatory, Los Angeles, Cal., p. 53.  
**DUTCH ISLAND, NARRAGANSETT BAY**, pp. 19, 20.  
**DYER'S ISLAND NARROWS, HARRINGTON, ME.**, p. 16.

## E.

**EAGRE (schooner).** Use of in Section I, pp. 15, 16; in Section II, p. 26; Appendix No. 5, pp. 117, 119, 120.  
**EARNEST (schooner).** Use of in Section XI, pp. 61, 62; laid up at Olympia, Wash. Ter., p. 62; see Appendix No. 5, p. 121.  
**EARTHQUAKE WAVES RECORDED BY SELF-REGISTERING TIDE-GAUGES**, p. 75; Appendix No. 4, p. 96.  
**EASTERN PASSAGE, HARRINGTON RIVER, ME.**, p. 16.  
**EAST MACHIAS, ME.**, p. 15.  
**EAST PORTLAND, OREG.**, p. 60.  
**EAST RIVER, N. Y., DANGEROUS ROCK DEVELOPED**, p. 5; re-survey of, reference to, in estimates, p. 11; examination of water front of, p. 25; topographic re-survey of shores of, p. 26; hydrographic re-survey of, p. 26.  
**EAST SAND ISLAND, MOBILE BAY**, p. 49.  
**EGAN, HON. RICHARD.** Courtesies received from, p. 52.  
**EIMBECK, WILLIAM, ASSISTANT.** Reconnaissance and triangulation in Utah, pp. 70, 71; base apparatus submitted by, p. 71; new form for suspension of pendulums, p. 71; Appendix No. 1, p. 86.  
**EICHHOLTZ, HUGO G.** Miscellaneous Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 111.  
**ELECTROTYPE PLATES MADE FOR DEPARTMENTS OF THE GOVERNMENT**, p. 5; Appendix No. 4, p. 98.  
**ELECTROTYPING.** Improvement in batteries for, p. 5; Appendix No. 4, pp. 95, 107, 108.  
**ELEVATOR.** Purchase of, Appendix No. 4, p. 98.  
**ELLCOTT, EUGENE, ASSISTANT.** Topographic work on coast of Maine, p. 15; between Norfolk and the ocean shore, p. 41; triangulation and shore-line topography, Saint John's River, Fla., from Nine Mile Point to Palatka, p. 43; Appendix No. 1, pp. 81, 83, 84.  
**ELLCOTT'S MAP OF THE DISTRICT OF COLUMBIA**, p. 38.  
**EMPIRE CITY, COOS BAY, OREG.**, p. 60.  
**ENDEAVOR (steamer).** Use of in Section II, pp. 27, 36; see Appendix No. 5, pp. 118, 119, 120.  
**ENGINEER CORPS, U. S. A.** Electrotypes plates made for, p. 5; Appendix No. 4, p. 96; connections made with survey of, pp. 68 and 69.  
**ENGLISHMAN'S BAY, ME.** Topographical survey of, p. 2, 15.  
**ENGRAVING DIVISION.** Improvements effected by Mr. Ogden, p. 75; report from, Appendix No. 4, pp. 107-110; list of plates completed, continued, or commenced during the fiscal year ending June 30, 1885. Appendix No. 4, pp. 109, 110.  
**ENGRAVING AND PRINTING OF CHARTS, COAST PILOTS, ETC.** Appendix No. 2, p. 88.  
**ENTHOFFER, E. J.** Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.  
**ENTHOFFER, JOSEPH.** Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.  
**ERICHSEN, P.** Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 105.  
**ERIN STATION, WIS.**, p. 169.  
**ESHLEMAN, E.** Instrument Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 105.  
**ESQUIMAULT HARBOR, STRAIT OF FUCA**, p. 63.  
**ESTERO BAY, FLA.** Referred to, in estimates, p. 10.  
**ESTIMATES.** Explanation of, pp. 8, 9; in detail, pp. 9-13.  
**ESTIMATES FOR OFFICE EXPENSES.** Reference to, Appendix No. 4, p. 98.  
**ESTIMATES FOR FIELD WORK.** Reference to, pp. 2, 8, 9.  
**EVANS, H. C.** Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.  
**EXAMINATION OF METHODS OF OBSERVATION AND PHOTOGRAPHIC PROCESSES EMPLOYED AT THE MAGNETIC OBSERVATORY, TORONTO, CANADA**, pp. 71, 72.  
**EXAMINATION OF THE MOVEMENTS OF ICE IN THE DELAWARE RIVER**, p. 32.  
**EXPLANATION OF ESTIMATES**, pp. 8, 9.  
**EXTENSION OF RECONNAISSANCE AND TRIANGULATION IN THE SOUTHERN PART OF THE STATE OF NEW JERSEY**, pp. 30, 31.  
**EXTENSION OF RECONNAISSANCE AND TRIANGULATION IN THE EASTERN PORTION OF THE STATE OF PENNSYLVANIA**, p. 31.  
**EXTENSION OF THE PRIMARY TRIANGULATION NEAR THE THIRTY-NINTH PARALLEL FROM WEST VIRGINIA INTO KENTUCKY AND OHIO**, pp. 41, 42.  
**EXTENSION OF THE PRIMARY TRIANGULATION NEAR THE THIRTY-NINTH PARALLEL EASTWARD ACROSS THE STATE OF ILLINOIS**, p. 68.

## F.

- FAGIN, V. J. Clerk in office of disbursing agent, Coast and Geodetic Survey, p. 76.
- FAIRFIELD, GEORGE A., ASSISTANT. Continuation of primary triangulation in the State of Illinois, p. 68; Appendix No. 1, p. 86.
- FAIRFIELD, W. B., EXTRA OBSERVER. Services in Section III, p. 41; in Section VI, p. 46; Appendix No. 1, pp. 83, 84; see also Appendix No. 4, pp. 99, 101.
- FALKNER'S ISLAND, LONG ISLAND SOUND, pp. 23, 24.
- FARMS (OR FROST) POINT, LONG ISLAND SOUND, p. 25.
- FARQUHAR, HENRY. Computing Division, Coast and Geodetic Survey Office, Appendix No. 4, pp. 99, 100.
- FECHTELER, A. F., ENSIGN, U. S. N. Hydrographic examinations in approaches to Newport, R. I., p. 21; off Terry, Rocky, and Horton's Points, Long Island, p. 22; off Cape Henry, Va., p. 41; deep-sea sounding and current work in the Gulf Stream, p. 45; see also Appendix No. 1, pp. 81, 82, 83, 84; Appendix No. 5, p. 118.
- FERNANDINA, FLA. Necessity for establishing tide-gauge at, Appendix No. 4, p. 102.
- FERREL, L. J. Tidal Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 103.
- FERREL, PROF. WILLIAM J. Reference to discussion of tides at Sandy Hook and on Pacific Coast, p. 7; in Penobscot Bay, p. 17; use of tide predictor invented by, p. 75; Appendix No. 4, p. 96; paper on the harmonic analysis of tides at Governor's Island, New York Harbor, Appendix No. 13, pp. 489-493.
- FIELD CATALOGUE OF TIME AND CIRCUMPOLAR STARS, preparation of new edition continued, p. 57.
- FIELD WORK, p. 2; pay of persons employed in, pp. 9, 10.
- FISCHER, LOUIS. Instrument Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 115.
- FISHER, W. J., TIDAL OBSERVER AT SAINT PAUL, KADIAK ISLAND, ALASKA, pp. 66, 85; Appendix No. 4, p. 102.
- FITZGERALD, W. G., p. 60.
- FLAT AND BACK BAYS. Hydrographic survey of, pp. 15, 16.
- FLEMER, J. A., AID. Service in Section III, p. 39.
- FLIP ROCK, OFF BASS POINT, NAHANT, MASS., pp. 5-17.
- FLORIDA. Reference to, in estimates, p. 10; triangulation and shore line topography Saint John's River between Nine Mile Point and Palatka, p. 43; hydrography of Saint John's River from Racy Point to Palatka, pp. 43, 44; beach measure and topography on west coast of Florida from Bowditch Point to Cape Romano, pp. 46, 47; hydrographic survey west coast of Florida from vicinity of Gordon's Pass to Cape Romano, p. 47; determination of gravity at Key West, p. 46; Appendix No. 5, p. 118.
- FORNEY, STEHMAN, ASSISTANT. Survey of coast of California from Moro Bay westward, p. 54; assistance rendered by, p. 55; Appendix No. 1, p. 85.
- FORSE, C. F., LIEUTENANT, U. S. N. Hydrographic survey in Hood's Canal, Wash., pp. 61, 62; Appendix No. 1, p. 85.
- FORTESCUE CREEK, N. J., p. 35.
- FORT FOSTER, ME., p. 15.
- FORT MIFFLIN, PA. Tidal observations at, Appendix No. 4, pp. 101, 102.
- FORT O'BRIEN, ME., p. 15.
- FORTRESS MONROE, VA. Lines of leveling run to, pp. 39, 40; gravity determinations at, p. 37.
- FORT SIMPSON, BRITISH COLUMBIA. Tidal observation at, Appendix No. 4, p. 102.
- FORT SMITH, ARK. Determination of longitude at, p. 49.
- FORT SUMTER, S. C. Tidal observations at, p. 43.
- FORT TRUMBULL, CONN. Tide-gauge removed from, p. 25.
- FOWEY ROCKS, northern end of Florida Reefs, pp. 44, 45.
- FOWLER, E. H. Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 105.
- FREMONT, J. C., LIEUTENANT, U. S. N. Appendix No. 5, p. 112.
- FRENCH, G. R., ENSIGN, U. S. N. Services in Section II, pp. 27, 37; in Section V, p. 43; in Section VI, p. 44; Appendix No. 1, pp. 83, 84.
- FRENCH, H. O. Miscellaneous Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 111.

- FRENCH, DR. WM. B. Office of Assistant in charge, p. 76; Appendix No. 4, p. 98.
- FROST (OR FARMS) POINT, LONG ISLAND SOUND, p. 25.
- FUNCK, JOS., p. 50.
- FURNISHING POINTS FOR STATE SURVEYS. Reference to, p. 2; in explanation of estimates, p. 8; in estimates, p. 11; in Massachusetts, p. 18.

## G.

- GALVESTON, TEX., p. 49-51.
- GARDINER'S BAY, LONG ISLAND. Shoaling near Constellation Rock, p. 20; re-survey in vicinity of, p. 21.
- GARRISON HILL, DOVER, N. H., p. 18.
- GAS ENGINE. Purchase of, Appendix No. 4, p. 98.
- GEBHART STATION, CABELL COUNTY, W. VA., p. 41.
- GEDNEY, C. D., STENOGRAPHER TO SUPERINTENDENT, p. 76.
- GEDNEY (steamer). Use of in Section VIII, pp. 50, 51; in Section IX, Appendix No. 5, p. 119.
- GENERAL STATEMENT OF PROGRESS, pp. 2-7.
- GEOGRAPHICAL POSITIONS AND HEIGHTS OF UPWARDS OF ONE THOUSAND STATIONS IN THE STATE OF MASSACHUSETTS, AND GEOGRAPHICAL POSITIONS OF ABOUT THREE HUNDRED STATIONS IN THE STATE OF RHODE ISLAND, p. 6; Appendix No. 8, pp. 285-439.
- GEOGRAPHICAL POSITIONS. Determination of, reference to, in estimates, p. 10.
- GEODETIC OPERATIONS IN NEW HAMPSHIRE, pp. 17, 18; in Vermont, p. 18; in New Jersey, p. 30, 31; in Pennsylvania, pp. 31, 32; in the District of Columbia, pp. 38, 39; from West Virginia into Kentucky and Ohio, pp. 41, 42; in California, pp. 55-57; in Tennessee, pp. 66, 67; in Ohio, p. 67; in Indiana, p. 67; in Illinois, p. 68; in Wisconsin, p. 69; in Missouri and Kansas, pp. 69, 70; in Utah, pp. 70, 71.
- GEODETIC WORK. Value of, reference to in explanation of estimates, p. 9; records and computations of, received in Coast and Geodetic Survey library, Appendix No. 4, p. 113.
- GEORGE'S SHOALS. Need of light upon, pp. 7, 30, 33.
- GILBERT, J. J., ASSISTANT. Topography of Hood's Canal, p. 61; reconnaissance of Olympic Mountains, p. 61; Appendix No. 1, p. 85.
- GILE STATION, NORWICH, VT., p. 18.
- GIRARD COLLEGE. Station at, p. 32; magnetic observations at, p. 34.
- GOLDSMITH'S INLET, LONG ISLAND, p. 22.
- GOODFELLOW, EDWARD, ASSISTANT. Services in preparation of annual report and in editing for publication the appendices thereto, p. 77.
- GORDON'S PASS, p. 47.
- GORE, PROF. J. H., VOLUNTEER AID, p. 41; Appendix No. 1, p. 83.
- GORGAS, MILES, ENSIGN, U. S. N. Ledge developed by, pp. 19, 20; location of wreck off Barnegat, p. 35; services in Section VI, p. 45; Appendix No. 1, pp. 81, 83, 84.
- GOSHEN CREEK, N. Y., p. 35.
- GOULD ISLAND, SAKONNET RIVER, R. I. Rock developed near, p. 19.
- GOULDSBORO', ME., pp. 3, 16, 17.
- GOVERNOR'S ISLAND, NEW YORK HARBOR. Discussion of tides at, p. 7; acknowledgment of courtesies received from officers in charge, p. 27; tidal observations at, p. 30; see Appendix No. 4, pp. 101, 102; Appendix No. 13, pp. 489-493.
- GRAHAM, A. B. Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 105.
- GRANGER, F. D., ASSISTANT. Triangulation in Section III, p. 42; in Missouri and Kansas, pp. 69, 70; Appendix No. 1, pp. 83, 86; Appendix No. 4, pp. 99, 101.
- GRAVITY DETERMINATIONS. At Washington, D. C., pp. 37, 38; at Fortress Monroe, Va., p. 37; at Key West, Fla., p. 46.
- GRAVITY EXPERIMENTS. Reference to, in estimates, p. 10.
- GRAY, E., TIDAL OBSERVER AT SAUCELITO, CAL., p. 58; Appendix No. 1, p. 85; Appendix No. 4, p. 102.
- GRAY, J. H., AID. Services in Section II, p. 26; in Section III, p. 41.

- GRAY, S. M., CITY ENGINEER, PROVIDENCE, R. I. In charge tide-gauge, p. 21; Appendix No. 4, p. 102.
- GREAT ABACO, BAHAMA ISLANDS, p. 44.
- GREAT BAHAMA BANK, p. 44.
- GREAT HOG NECK, LONG ISLAND, p. 21.
- GREAT ROUND SHOAL, VINEYARD SOUND, pp. 5, 20.
- GREAT SPRUCE ISLAND, p. 15.
- GREAT WASS ISLAND, p. 16.
- GREENPORT, LONG ISLAND. Topographical survey in vicinity of, pp. 23, 24.
- GRIFFIN, T. D., ENSIGN, U. S. N. Services in Section I, p. 16; in Section VI, p. 47; in Section VIII, p. 49, Appendix No. 1, pp. 81, 84.
- GUILFORD, CONN. Re-survey in vicinity of, pp. 23, 24.
- GULF OF MAINE. Laws of tidal action and physical hydrography of, p. 17.
- GULF OF MEXICO. Reference to, in estimates, p. 9; connection of triangulation of coast of, with that along the Blue Ridge, p. 48; connection of point on the coast of, with the transcontinental line of levels, pp. 68, 69; distribution of parties on the coast of, p. 2; Appendix No. 1, pp. 81-86; model of depths of sea in, reference to, pp. 73 and 74.
- GULF STREAM. Investigation of the currents of, p. 2; reference to, in estimates, p. 10; deep-sea soundings and current observations in, pp. 4, 44-46; see also Appendix No. 5, p. 119, and Appendix No. 14, pp. 495-501.
- GUN CAY, BAHAMAS, p. 44-46.
- II.
- HAGERSTOWN, MD., p. 39.
- HALIFAX ISLAND, ENGLISHMAN'S BAY, ME., p. 15.
- HALL, A. L., ENSIGN, U. S. N. Services in Section II, p. 37; in Section VIII, p. 51; Appendix No. 1, pp. 83, 84.
- HALTER, R. E., ASSISTANT. Triangulation and wire measurement between Point Isabel and Brownsville, Tex., pp. 51, 52; Appendix No. 1, p. 84.
- HAMAHAMA RIVER, WASH. TER., p. 61.
- HAMMONASSETT POINT, LONG ISLAND SOUND, pp. 24, 28.
- HANUS, G. C., LIEUTENANT, U. S. N. Hydrographic re-survey, New York Bay, p. 27; Lower Delaware Bay and entrance, pp. 26, 37; in Stone and Wadmelaw Rivers, S. C., p. 42; Saint John's River, Fla., from Racy Point to Palatka, pp. 43, 44; Appendix No. 1, pp. 82, 83, 84; Appendix No. 5, pp. 118, 119, 120.
- HARBOR AND LAND COMMISSION OF MASSACHUSETTS. Assistant Whiting's services in, p. 18.
- HARMONIC ANALYSIS OF TIDES AT GOVERNOR'S ISLAND, NEW YORK HARBOR, p. 7; Appendix No. 13, pp. 489-493.
- HARRINGTON RIVER, ME. Hydrographic survey in, pp. 15, 16.
- HARVEY, R. M., IN CHARGE OF ARCHIVES, COAST AND GEODETIC SURVEY OFFICE, Appendix No. 4, p. 97.
- HASSLER (steamer). Service in Section XI, pp. 63, 64, 65; Appendix No. 5, p. 121.
- HAWAIIAN GOVERNMENT SURVEY, pp. 57, 75; Appendix No. 1, p. 86.
- HAWLEY, J. M., LIEUTENANT, U. S. N. Hydrographic re-survey in East River, N. Y., p. 26; Appendix No. 1, p. 82; Appendix No. 5, pp. 119, 120.
- HAZEL POINT, WASH., p. 61.
- HEALD, E. D. F., LIEUTENANT, U. S. N. Hydrographic surveys in Narraganset, Harrington, and Pleasant Rivers, Me., pp. 15, 16; on west coast of Florida from Gordon's Pass to Cape Romano, p. 47; in Mobile Bay and around the Chandeleur Islands, pp. 48, 49; see Appendix No. 1, pp. 81, 84; Appendix No. 5, pp. 117, 118.
- HERGESHEIMER, E., ASSISTANT. Topographical re-survey north shore of Long Island Sound westward from Farms (or Frost) Point and including the Norwalk Islands; examination of water front of East River, N. Y., pp. 25, 26; topographical re-survey of East River from Red Hook to Throg's Neck, p. 26; Appendix No. 1, p. 82.
- HERGESHEIMER, JOSEPH, ASSISTANT. Topographical re-survey of the shore lines of Coney Island and Rockaway Beach, New York Lower Bay, p. 27; beach measure and topography on west coast of Florida from Bowditch Point to Cape Romano, pp. 46, 47, Appendix No. 1, pp. 83, 84.
- HELM, J. M., LIEUTENANT, U. S. N. Services in section XII, p. 66.
- HETHERINGTON, J. H., ENSIGN, U. S. N. Services in section II, p. 37; in Section VIII, p. 51; Appendix No. 1, pp. 83, 84.
- HILL, C. B., ACTING AID. Services in Section X, pp. 56, 57, 58; Appendix No. 1, p. 85.
- HITCHCOCK (steamer). Service in Section VIII, p. 50; Appendix No. 5, p. 120.
- HODGKINS, W. C., SUBASSISTANT. Topographical re-survey in vicinity Lyme and Saybrook, Conn., p. 22; Appendix No. 1, p. 82.
- HOLABIRD, SAMUEL B., QUARTERMASTER-GENERAL U. S. A., Appendix No. 5, p. 120.
- HOLLISTER PEAK, CAL., p. 53.
- HONEY CREEK, ILL., p. 68.
- HONOLULU, SANDWICH ISLANDS. Tidal observations at, p. 75; Appendix No. 4, pp. 96, 102.
- HOOD'S CANAL, WASH. TER. Topography and hydrography of, pp. 61, 62.
- HOONIAH SOUND, ALASKA, p. 5.
- HOOVER, D. N. Printing office, Coast and Geodetic Survey, Appendix No. 4, p. 107.
- HORTON'S POINT, LONG ISLAND. Hydrographic work off, p. 22.
- HOSMER, CHARLES, ASSISTANT. Topographical re-survey in Long Island Sound, pp. 21, 26; Appendix No. 1, p. 82.
- HOUSATONIC RIVER, CONN., p. 23.
- HOUSE STATION, TENN., p. 66.
- HUMBOLDT BAY, CAL. Survey in, p. 58.
- HUNT CITY STATION, ILL., p. 68.
- HUNTINGTON, LONG ISLAND, p. 23.
- HYDROGRAPHIC DIVISION, COAST AND GEODETIC SURVEY OFFICE. Reference to, p. 14; report from, Appendix No. 5, pp. 117-128.
- HYDROGRAPHIC EXAMINATIONS. In York Harbor, Me., p. 17; between Marblehead Rock and Marblehead Neck, Mass., p. 17; off Bass Point, Nahant, Mass., p. 17; in Vineyard Sound, p. 19; in Narraganset Bay, pp. 19, 20; in Block Island Sound, p. 20; off Cape Henry, Va., p. 41; in the approaches to Newport, R. I., p. 21; off Terry, Rocky, and Horton's Points, Long Island, p. 22; see Appendix No. 5.
- HYDROGRAPHIC INSPECTOR. Reference to, p. 14; reference to appointment of, Appendix No. 5, p. 119; report from, Appendix No. 5, pp. 117-128.
- HYDROGRAPHIC OFFICE, NAVY DEPARTMENT, p. 5; Appendix No. 4, p. 98.
- HYDROGRAPHIC RECORDS. See report from Archives Coast and Geodetic Survey Office, Appendix No. 4, p. 113.
- HYDROGRAPHIC SHEETS PLOTTED, VERIFIED, AND INKED DURING THE FISCAL YEAR ENDING JUNE 30, 1885; Appendix No. 5, pp. 123, 124.
- HYDROGRAPHIC SURVEYS AND RE-SURVEYS. Narraganset River, from Millbridge to Cherryfield; Harrington River, including Flat and Back Bays, and Pleasant River, to Addison, Me., pp. 15, 16; survey north coast of Long Island Sound, from Hammonasset Point to Welch's Point, p. 24; re-survey of East River, N. Y., pp. 26, 27; of entrance to New York Bay, p. 27; of North River, N. Y., p. 28; of Lower Delaware Bay and entrance, p. 36; survey in Stone and Wadmelaw River, S. C., pp. 42, 43; of Saint John's River, Fla., from Racy Point to Palatka, p. 43; of west coast of Florida from vicinity of Gordon's Pass to Cape Romano, p. 47; in Mobile Bay and around the Chandeleur Islands, pp. 48, 49; off the coast of Louisiana from Sabine Pass eastward, pp. 50, 51; of the California coast in the vicinity of San Simeon, pp. 54, 55; in Humboldt Bay, Cal., between Brushy Point and White Rock, p. 58; of Willamette River, pp. 60, 61; Hood's Canal, Wash. Ter., pp. 61, 62; in Strait of Fuca, pp. 64, 65; in South-eastern Alaska, pp. 65, 66.
- HYDROGRAPHY. Statistics of, Appendix No. 2, pp. 87, 88; Appendix No. 4, p. 113.
- HYDROLOGICAL SURVEY, NEW YORK BAY AND HARBOR, pp. 28, 29.

## I.

- IARDELLA, C. T., ASSISTANT. Topographical re-survey of the western shore of Delaware Bay, p. 36; Appendix No. 1, p. 83.
- IBEPAH—MOUNT NEBO, triangulation line, pp. 70, 71.
- ICE. Movements of, in the Delaware River, p. 32.
- ILLINOIS. Extension of the primary triangulation near the thirty-ninth parallel eastward across, p. 68.
- IMPORTANT DEVELOPMENTS. Reference to, p. 2, p. 5.
- INDIANA. Geodetic operations in, pp. 67, 58.
- INFORMATION FURNISHED TO DEPARTMENTS OF THE GOVERNMENT IN REPLY TO SPECIAL REQUESTS, AND TO INDIVIDUALS UPON APPLICATION DURING THE FISCAL YEAR ENDING JUNE 30, 1885, pp. 4, 75, 76; Appendix No. 3, pp. 89-93.
- INSHORE HYDROGRAPHIC SURVEY OF THE NORTHERN COAST OF LONG ISLAND SOUND, FROM HAMMONASSETT POINT TO WELCH'S POINT, pp. 24, 25.
- INSTRUMENT DIVISION, COAST AND GEODETIC SURVEY OFFICE. Reference to; Appendix 4, p. 96; report from, Appendix No. 4, pp. 114, 115.
- INSTRUMENT ROOM. Reference to improvement in, p. 5.
- INTERIOR STATES. General statement of progress of work in, p. 4; distribution of parties in, reference to, p. 2; Appendix No. 1, pp. 81-86.
- INTERNATIONAL ELECTRIC EXHIBITION AT PHILADELPHIA. Magnetic observations made for, p. 34.
- INVESTIGATION OF THE CURRENTS OF THE GULF STREAM, pp. 2, 4, 44-46; Appendix No. 5, p. 119. Appendix No. 14, pp. 495-501.
- IRVING, ESTRADA, p. 54.

## J.

- JAMES ISLAND LIGHT, p. 41.
- JAPAN STREAM. Reference to, in estimates, p. 9.
- JEFFRIES, A. ENSIGN, U. S. N. Services in Section I, p. 16; in Section VI, p. 47; in Section VIII, p. 49; Appendix No. 1, pp. 81, 84.
- JORDAN'S DELIGHT LEDGE, p. 16.
- JORDAN, J. N., ENSIGN, U. S. N. Services in Section X, pp. 58, 59; in Section XI, pp. 61, 62; Appendix No. 1, p. 85.
- JUNKEN, CHAS., ACTING ASSISTANT. Determination of points on the boundary line between Maryland and Virginia, pp. 40, 41; Appendix No. 1, p. 83; Appendix No. 4, p. 104.
- JUPITER INLET, p. 44.

## K.

- KALAMAZOO, MICH. Magnetic observations at, p. 72.
- KANSAS. Primary triangulation near the thirty-ninth parallel, pp. 69, 70.
- KANSAS CITY, MO. Determination of longitude at, p. 70.
- KARCHER, LOUIS. Drawing Division, Coast and Geodetic Survey, Appendix No. 4, p. 103.
- KARTA BAY, ALASKA, p. 66.
- KEARNEY, S. Instrument Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 115.
- KEARSARGE, N. H., p. 17.
- KELLOGG, F. W., ENSIGN, U. S. N. Services in Section I, p. 21; in Section II, p. 22; Appendix No. 1, pp. 81, 82.
- KELLOGG—RUSSIA, line of triangulation, p. 31.
- KENTUCKY. Primary triangulation near the thirty-ninth parallel, pp. 41, 42; reconnaissance for extension of, p. 66.
- KEY WEST, FLA. Determination of gravity at, p. 46.
- KINCHELOE (sloop). Use of, in Section XI, pp. 60, 61.
- KNIGHT, H. M. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- KOCH AND NETTIE, MORGAN STEAMSHIP LINE. Acknowledgment of assistance rendered by, p. 50.
- KRAKATOA. Earthquake waves from, recorded on tide-gauges at Saucelito, Honolulu, and Saint Paul, p. 75; Appendix No. 4, p. 96.
- KUMMELL, CHARLES H. Computing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 100.

## L.

- LAGUNA CAÑON, CAL., p. 52.
- LANGE, G., LIEUTENANT, NORWEGIAN GENERAL STAFF. Services in topographical re-survey north shore Long Island Sound, p. 24.

LAKE SURVEY. Connections made with triangulation of, pp. 68 and 69.

LAWSON, JAS. S., ASSISTANT. Primary triangulation coast of California north of Point Concepcion, pp. 53, 54; Appendix No. 1, p. 85.

LEDGES AND SHOALS DEVELOPED, pp. 2, 5, 17, 19, 20, 21, 24, 25, 47.

LEFAVOR, F. H., LIEUTENANT, U. S. N. Services in Section X, p. 55; Appendix No. 1, p. 85.

LEFAVOUR, E. B. Weights and Measures Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 115.

LEIPER, E. F., ENSIGN, U. S. N. Service in Section II, pp. 27, 37; in Section V, p. 43; in Section VI, p. 43; Appendix No. 1, pp. 83, 84; Appendix No. 5, p. 119.

LEVELING. Reference to, in estimates, p. 10; line carried from Ashland, Va., to Fortress Monroe, pp. 39, 40; to connect benchmark near Washington Aqueduct bridge with Capitol Bench-mark, pp. 39, 40; for connecting transcontinental line of levels with a point on the Gulf coast, pp. 68, 69.

L'HOMME DIEU SHOAL. Examination near, pp. 19, 20.

LIBRARY, COAST AND GEODETIC SURVEY. Room fitted up for, Appendix No. 4, p. 98; see report of Archives and Library, Appendix No. 4, pp. 112-114.

LIGHT HOUSE BOARD. Examinations required by, reference to, in estimates, p. 10; transfer of steamer Daisy from, to Coast and Geodetic Survey, Appendix No. 5, p. 120.

LIST OF PUBLICATIONS OF THE COAST AND GEODETIC SURVEY RECEIVED FROM THE PUBLIC PRINTER DURING FISCAL YEAR ENDING JUNE 30, 1885, Appendix No. 4, p. 112.

LIST OF PLATES COMPLETED, CONTINUED OR COMMENCED DURING FISCAL YEAR ENDING JUNE 30, 1885, Appendix No. 4, pp. 109, 110.

LIST OF HYDROGRAPHIC SHEETS RECEIVED AND DEPOSITED IN THE ARCHIVES, Appendix No. 4, p. 114.

LINDENKOHL, A., Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 104.

LINDENKOHL, H., Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 104.

LINES OF LEVELING OF PRECISION CARRIED FROM ASHLAND, VA., TO FORTRESS MONROE, pp. 39, 40; to connect benchmark near Washington Aqueduct Bridge with Capitol bench-mark, pp. 39, 40; for connecting transcontinental line of levels with a point on the Gulf Coast, pp. 68, 69.

LITTLE ROCK, ARK., determination of longitude of, pp. 49, 70.

LIVELY (steam tender). Service in Section XII, p. 55.

LLOYD'S NECK, LONG ISLAND. Topographical re-survey eastward from, pp. 22, 23; triangulation from, towards New Rochelle, N. Y., p. 26.

LOCATION OF WRECK OFF BARNEGAT, p. 35.

LONGFELLOW, A. W., ASSISTANT. Topographical survey in Maine, pp. 16, 17; Appendix No. 1, p. 81.

LONG ISLAND. Topographical re-survey of the northeastern coast of, in vicinity of Gardiner's Bay, Shelter Island and Greenport; pp. 21, 22; of the north shore of, to the west of Greenport, p. 22; hydrographic examinations off Terry, Rocky, and Horton's Points, p. 22; see Appendix No. 1, p. 82.

LONG ISLAND SOUND. Advance of re-survey of, p. 2; ledges and shoals developed, pp. 2, 5, 24, 25; topographical re-surveys on the north shore of, at the mouth of the Connecticut River and near Milford and Stratford; also from Lloyd's Neck eastward on the south shore, pp. 22, 23; of the north shore of, in the vicinity of Madison, Guilford and Branford, Conn., pp. 23, 24; of the north shore, westward from Frost (or Farms) Point and including the Norwalk Islands, pp. 25, 26; of the north shore, from Darien, Conn., toward New Rochelle, pp. 21, 22, 26; inshore hydrographic survey of northern coast of, from Hammonasset Point to Welch's Point, pp. 24, 25; triangulation in the western part of, from Lloyd's Neck towards New Rochelle, p. 26; reference to, in estimates, p. 10; see Appendix No. 1, p. 82, Appendix No. 5, pp. 117, 118.

LONGITUDES. Determination of, for stations at Little Rock, Texarkana, Fort Smith, Ark., pp. 49, 50; at Brownsville, Tex., p. 51; at Kansas City, Mo., p. 70.

LONGITUDE OF A STATION OF THE HAWAIIAN GOVERNMENT SURVEY, p. 57.

LONGITUDE PARTIES, reference to, in estimates, p. 10.

LONG, W. M., Miscellaneous Division, Coast and Geodetic Survey Office, Appendix, No. 4, p. 11.  
 LOS ANGELES, CAL., magnetic observations at, pp. 52, 53.  
 LOUISIANA. Reference to, in estimates, p. 10; triangulation and topography of the coast of, from Côté Blanche Bay to the westward, p. 50; hydrographic survey of the coast of, from Sabine Pass to the eastward, pp. 50, 51; Appendix No. 5, pp. 118, 119.  
 LUCAS SHOAL, VINEYARD SOUND, p. 19.  
 LUTZ STATION, CLARK COUNTY, IND., p. 22.  
 LYNNHAVEN RIVER, VA., p. 41.

## M.

MACHIAS BAY, ME., reference to, in estimates, p. 10; topography of, pp. 14, 15.  
 MACHIAS, EAST, p. 15.  
 MACHIAS, PORT, p. 14, 15.  
 MACLENNAN, WM. F., representative of Treasury Department at the New Orleans Exposition, p. 73.  
 MADISON, CONN. Topographical re-survey in vicinity of, pp. 23, 24, 25.  
 MAEDDEL, E. A. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.  
 MAGNETIC DISCUSSIONS. Reference to, pp. 4, 6; Appendix No. 4, pp. 95, 99; see Appendix No. 6, pp. 129-274.  
 MAGNETIC MAP OF NORTH AMERICA. Reference to, in estimates, p. 9.  
 MAGNETIC OBSERVATIONS. At Providence, R. I., p. 20; Coasters' Harbor Island, Narragansett Bay, p. 20; at Philadelphia, Pa., p. 34; at station on New Jersey coast, p. 35; at Washington, D. C., pp. 24, 38; at Los Angeles, Cal., pp. 52, 53; at the Presidio of San Francisco, Cal., p. 57; in Utah, p. 71; at Kalamazoo, Mich., p. 72; see Appendix No. 2, p. 87; Appendix No. 4, p. 113.  
 MAGNETIC OBSERVATORY, TORONTO, CANADA, pp. 4, 71, 72.  
 MAGNETIC WORK, STATISTICS OF. Appendix No. 2, p. 87; Appendix No. 4, p. 118.  
 MAIN SHIP CHANNEL, VINEYARD SOUND, p. 5.  
 MAINE. Topography of Machias Bay entrance, Machiasport and the coast to the eastward, 14, 15; of Chandler's Bay and Englishman's Bay, p. 15; in vicinity of Prospect Harbor, Gouldsborough, and re-survey of Bar Harbor, Mount Desert Island, pp. 16, 17; hydrographic survey of Narragansett River from Millbridge to Cherryfield; of Harrington River, including Flat and Back Bays, and of Pleasant River to Addison, pp. 15, 16; hydrographic examinations off the coast of, p. 17; tidal observations at Pulpit Cove, North Haven Island, Penobscot Bay, p. 17; Appendix No. 1, p. 81; Appendix No. 5, p. 117.  
 MANSFIELD, H. B., LIEUTENANT, U. S. N., Appendix No. 5, p. 118.  
 MAP OF THE UNITED STATES. Reference to progress made, Appendix No. 4, p. 97.  
 MAPS AND CHARTS. Number of, Appendix No. 2, p. 88.  
 MARBLEHEAD, MASS. Location of rock near, pp. 5, 17.  
 MARINDIN, HENRY L., ASSISTANT. Hydrological survey New York Bay and Harbor, p. 28; of Delaware River and Bay, pp. 7, 32-34; re-survey New York Bay and Harbor, p. 34; survey of the Delaware above Bridesburg, duties as consulting engineer of the U. S. Advisory Commission for port-warden lines for the harbor of Philadelphia, pp. 33, 34; see Appendix No. 1, pp. 82, 83; current observations New York Harbor, Appendix No. 5, p. 120.  
 MARITIME EXCHANGE, NEW YORK, p. 72.  
 MARITIME EXCHANGE, PHILADELPHIA, p. 73.  
 MARR, R. A., SURASSISTANT. Services in Section X, pp. 56, 57; in Section XII, p. 66; Appendix No. 1, p. 85.  
 MARSH, C. C., ENSIGN, U. S. N. Service in Section XII, p. 66; Appendix No. 1, p. 85.  
 MARSH LAND. Measurement of amount of, on the Atlantic and Gulf coasts, p. 76; Appendix No. 4, p. 97.  
 MARYLAND. Determination of points on the boundary line between Virginia and, pp. 40, 41.  
 MASSACHUSETTS. Examinations off the coast of, pp. 2, 17, 19; trigonometrical operations in aid of the State Survey of, pp. 18, 19; geographical positions in, p. 6; see Appendix No. 8, pp. 285-439.

## H. Ex. 18—III

MATCHLESS (schooner). Appendix No. 5, p. 120.  
 MAUCH CHUNK, CARBON COUNTY, PA., p. 31.  
 MAXFIELD, J. E., Appendix No. 4, p. 99.  
 MCARTHUR (steamer). Use of in Section X, pp. 54, 58, 59; Appendix No. 5, p. 121.  
 MCCORKLE, S. C., ASSISTANT. Examination of ice movement in the Delaware River, p. 32; reconnaissance in and around Philadelphia, p. 32; charge of sub office at Philadelphia, pp. 72, 73; Appendix No. 1, pp. 83, 86.  
 McGRATH, J. E., AID. Services in Section III, pp. 41, 42; in Section XIII, p. 66; measurement of marsh land and preparation of projection tables, Appendix No. 4, p. 97; Appendix No. 1, pp. 83, 85.  
 McLEAN, WALTER, ENSIGN, U. S. N. Services in Section XII, p. 66; Appendix No. 1, p. 85.  
 McNUTT, F. A., ENSIGN, U. S. N. Services in Section X, pp. 58, 59; Appendix No. 1, p. 85.  
 MEETING HOUSE-PRINCIPIO, line of triangulation, p. 31.  
 MELTON STATION, ROANE COUNTY, TENN., p. 66.  
 MENESEE, D. P., ENSIGN, U. S. N. Services in Section XII, p. 66; Appendix No. 1, p. 85.  
 MERRIMAN, PROF. MANSFIELD, ACTING ASSISTANT. Reconnaissance and triangulation in Pennsylvania, p. 31; Appendix No. 1, p. 82.  
 MERMENTAU RIVER, p. 51.  
 MERWIN'S POINT, CONN., p. 23.  
 MILFORD, CONN. Topographical re-survey near, pp. 22, 23.  
 MILLBRIDGE, ME., pp. 15, 16.  
 MILLER, CAPT. J. N., U. S. N., p. 21.  
 MISCELLANEOUS DIVISION. Report from, Appendix No. 4, pp. 110-112.  
 MISSPILLION CREEK, DELAWARE BAY, p. 36.  
 MISSPILLION LIGHT, p. 36.  
 MISSION BAY, CAL. Examination for rocks in, p. 57.  
 MISSISSIPPI RIVER COMMISSION. Experts in river gauging supplied by, p. 28; Coast and Geodetic Survey represented upon, p. 29.  
 MISSOURI. Primary triangulation near the thirty-ninth parallel, pp. 69, 70; longitude of station at Kansas City determined, p. 70.  
 MITCHELL, HENRY, ASSISTANT. Hydrological survey New York Bay and Harbor, p. 28; of Delaware River and Bay, pp. 7, 32-34; member U. S. Advisory Committee to the Harbor Commission of Philadelphia, p. 34; in charge of suboffice at Boston, p. 72; Appendix No. 1, pp. 82, 83, 86; need of a light on Saint George's Bank, pp. 7, 29, Appendix No. 11, pp. 483-485.  
 MOBILE BAY. Hydrographic work in, p. 49; Appendix No. 5, p. 118.  
 MOKKOW, E. Drawing Division, Coast and Geodetic Survey Office, p. 105.  
 MONOMOY SHOALS, NANTUCKET SOUND. Reference to, in estimates, p. 10; examination to determine laws of tidal and current action, pp. 28, 29.  
 MOORE, F. Printing Office, Coast and Geodetic Survey, Appendix No. 4, p. 107.  
 MOOSI-LAUK, N. H., p. 18.  
 MORGAN, WILLIAM B., DISBURSING AGENT, COAST AND GEODETIC SURVEY, p. 76.  
 MORO BAY CAL., p. 54.  
 MORSE, FREMONT, AID. Services in Section X, pp. 56, 57; Appendix No. 1, p. 85.  
 MOSER, JEFF. F., LIEUTENANT U. S. N. Reference to services of, pp. 14, 27; in office of Hydrographic Inspector, Appendix No. 5, p. 122.  
 MOSMAN, A. T., ASSISTANT. Primary triangulation near thirty-ninth parallel from West Virginia into Kentucky and Ohio, pp. 41, 42; reconnaissance for primary triangulation near thirty-ninth parallel, pp. 66, 67; Appendix No. 1, pp. 83, 85.  
 MOSMAN, P. A. Service in Section III, p. 41.  
 MOUNT DESERT ISLAND, p. 16, 17.  
 MOUNT DIABLO STATION, CAL., p. 56.  
 MOUNT ELLINOR, WASH., p. 61.  
 MOUNT HOLLY STATION, N. J., p. 31.  
 MOUNT HOLLY-GIRARD COLLEGE, line of triangulation, p. 32.  
 MOUNT MISERY, MD., p. 31.  
 MOUNT NEBO, p. 71.  
 MOUNT VERNON, ALA., p. 48.  
 MUCKILTEO-TURKEY, line of triangulation, p. 82.



## N.

NAHANT, MASS. Directions for avoiding rock in vicinity of, p. 5; hydrographic examination of, p. 17.  
 NANTUXENT CREEK, N. J., p. 36.  
 NARRAGANSETT BAY. Hydrographic examinations in, pp. 19, 20; Appendix No. 5, pp. 117, 118.  
 NARRAGAUGUS RIVER, ME. Hydrographic survey in, pp. 15, 16.  
 NATIONAL ACADEMY OF SCIENCES. Memoir presented at meeting of, by Assistant C. S. Peirce, p. 38.  
 NAVAL OFFICERS ON COAST SURVEY SERVICE. Appendix No. 5, pp. 125, 127; number attached to Coast Survey vessels during the year ending June 30, 1885, Appendix No. 5, p. 128.  
 NAVY DEPARTMENT, Hydrographic Office of, electrotype plates made for, p. 5; Appendix No. 4, p. 98.  
 NEEAH BAY, STRAIT OF FUCA, p. 63.  
 NELL'S ISLAND, HOUSATONIC RIVER, p. 23.  
 NELSON, JOHN, AID. Services in Section III, p. 40, in Section XIV, p. 69; Appendix No. 1, pp. 83, 86; Appendix No. 4, pp. 90, 101.  
 NELTIE, MR., OF MORGAN STEAMSHIP LINE, p. 50.  
 NEVA STRAIT, ALASKA, p. 5.  
 NEW DUNGENESS LIGHT, STRAIT OF FUCA, p. 64.  
 NEW HAMPSHIRE. Geodetic operations in, pp. 17, 18; hydrographic examinations off the coast of, p. 17.  
 NEW HAVEN, CONN., pp. 23, 24.  
 NEW HAVEN BREAKWATER. Tidal observations at, p. 25; see Appendix No. 4, pp. 101, 102.  
 NEW JERSEY. Progress of work in, p. 3; reference to, in estimates, p. 10; topographical re-survey of Sandy Hook, p. 30; tidal observations at Sandy Hook, p. 30; reconnaissance and triangulation, pp. 30, 31, 35; magnetic observations, p. 35.  
 NEW ORLEANS EXPOSITION. Coast Survey exhibit at, pp. 4, 73, 74; instruments sent to, Appendix No. 4, p. 97.  
 NEWPORT BAY, CAL., connected with work at San Juan Capistrano, p. 52.  
 NEWPORT, R. I. Hydrographic examination in the approaches to, p. 21; observations of magnetic variation for new chart of harbor of, pp. 20, 21.  
 NEW ROCHELLE, N. Y., pp. 22, 26.  
 NEWTOWN-MOUNT ROSE, line of triangulation, p. 31.  
 NEW YORK. Progress of work in, p. 3; suboffice at, pp. 4, 72; hydrographic re-survey of East River, p. 26; topographical re-survey of shores of East River, p. 26; hydrographic re-survey of North River, p. 28; topographical re-survey of the shores of North River, p. 28.  
 NEW YORK BAY AND HARBOR. Re-survey of, p. 2; reference to, in explanation of estimates, pp. 8, 9; in detailed estimates, p. 11; hydrographic re-survey, p. 27; physical hydrography of, pp. 28, 29; Appendix No. 5, pp. 118, 119.  
 NEW YORK LOWER BAY. Determination of points for re-survey of, p. 27; topographical re-survey of shore lines of Coney Island and Rockaway Beach, p. 27.  
 NIBLACK, A. P., ENSIGN, U. S. N. Services in Section XII, p. 66; Appendix No. 1, p. 85.  
 NINE MILE POINT, FLA., p. 43.  
 NOBSKA LIGHT HOUSE. Examination near, pp. 5, 19, 20.  
 NORFOLK, VA. Topographical survey between, and the ocean shore, p. 41.  
 NORTH AMERICA. Magnetic map of, reference to, in estimates, p. 9.  
 NORTH CAROLINA. Reference to, in estimates, p. 10.  
 NORTH CONWAY, N. H., p. 17.  
 NORTH HAMPTON, N. H. Hydrographic examination of, p. 17.  
 NORTH RIVER, N. Y. Hydrographic re-survey of, p. 28; topographical re-survey of shores of, p. 28.  
 NORTHWEST PROVIDENCE CHANNEL. Deep-sea soundings in, p. 44.  
 NORTHWEST REEF, LONG ISLAND SOUND, pp. 5, 25.  
 NORWALK ISLANDS, LONG ISLAND SOUND, p. 25.  
 NOTICES TO MARINERS, pp. 5, 17, 19, 20, 21, 24, 25, 47; number of copies printed, Appendix No. 4, p. 112.  
 NUMBER OF NAVAL OFFICERS ATTACHED TO COAST SURVEY VESSELS DURING THE YEAR ENDING JUNE 30, 1885, Appendix No. 5, p. 128.

NUMBER OF MEN ATTACHED TO COAST SURVEY VESSELS DURING THE YEAR ENDING JUNE 30, 1885, Appendix No. 5, p. 128.

## O.

OAKLAND STATION, BOYD COUNTY, KY., p. 41.  
 OCCUPATION OF STATIONS. In continuation of the primary triangulation of the coast of California, pp. 55-57.  
 OCCUPATION OF STATIONS. In continuation of the triangulation of the State of Tennessee, pp. 66, 67.  
 OCCUPATION OF STATIONS. In continuation of the triangulation of the State of Indiana, pp. 67, 68.  
 OCCUPATION OF STATIONS. In continuation of the triangulation of the State of Wisconsin, p. 69.  
 OCCUPATION OF STATIONS. For continuing to the westward the primary triangulation in Missouri and Kansas, pp. 69, 70.  
 ODIN, ILL., p. 69.  
 OFFICE BUILDING. Rent of, reference to, in estimates, p. 13.  
 OFFICE EXPENSES. Reference to, in estimates, p. 12; reduction in, Appendix No. 4, p. 98.  
 OFFICE WORK, p. 4; Appendix No. 4, pp. 95-116.  
 OGDEN, H. G., ASSISTANT. Reference to, p. 75; Appendix No. 4, p. 95; report of Engraving Division, Appendix No. 4, pp. 107-110.  
 OGDEN STATION, UTAH, pp. 70, 71.  
 OHIO. Primary triangulation near the thirty-ninth parallel, pp. 41, 42; reconnaissance for extension of, pp. 66, 67; triangulation of State of, p. 67.  
 OLGA STRAIT, ALASKA, p. 5.  
 OLYMPIC MOUNTAINS, OREG. Reconnaissance of, p. 61; characteristics of, p. 64.  
 ON A DEVICE FOR ABBREVIATING TIME REDUCTIONS, Appendix No. 15, pp. 503-508.  
 ON DEEP-SEA CURRENT WORK IN THE GULF STREAM, Appendix No. 14, pp. 495-501.  
 ON GEODETIC RECONNAISSANCE, Appendix No. 10, pp. 489-491.  
 ON THE EFFECT OF UNEQUAL TEMPERATURE ON A REVERSIBLE PENDULUM, Appendix No. 17, pp. 511-512.  
 ON THE HARMONIC ANALYSIS OF THE TIDES AT GOVERNOR'S ISLAND, NEW YORK HARBOR, Appendix No. 13, pp. 489-493.  
 ON THE INFLUENCE OF A NODDY ON THE PERIOD OF A PENDULUM, Appendix No. 16, pp. 509-510.  
 OGLEHAMIE MAGNETIC WORK, Appendix No. 4, pp. 99-101.  
 ORCHARD, J. M., ENSIGN, U. S. N. Services in Section VI, p. 47; in Section VIII, p. 49; Appendix No. 1, p. 84; Appendix No. 5, p. 118.  
 OREGON. Triangulation and topography of the Umpqua River, pp. 59, 60; geographical position of Yaquina light-house determined, p. 57.  
 OSSISPEE (U. S. steamer). Where grounded, p. 41; Appendix No. 5, p. 118.  
 O'SULLIVAN, T. J. Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, pp. 104, 105.  
 OVER, FRANK. Electrotype Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.  
 OWEN STATION, MONROE COUNTY, TENN., p. 66.

## P.

PACIFIC COAST. Progress of work on, p. 4; reference to, in estimates, pp. 9, 10; distribution of parties on, p. 2; Appendix No. 1, pp. 81-86.  
 PAINE, S. C., LIEUTENANT, U. S. N., Appendix No. 5, p. 117.  
 PALATKA, FLA., pp. 43, 44.  
 PALINURUS (schooner). Use of, in Section II, pp. 24, 25, 28; see Appendix No. 5, pp. 117-128.  
 PALMER, FRANCIS J., ACTING ASSISTANT. In charge of suboffice at New York, p. 72; Appendix No. 1, p. 86.  
 PARSONS, F. H., SUBASSISTANT. In office of Assistant in charge, p. 76; Appendix No. 1, p. 83; Appendix No. 4, p. 98.  
 PARSONS, J. W., ACCOUNTANT, p. 76.  
 PART I. Report for 1885, pp. 1-13; Part II, Report for 1885, pp. 14-77; Part III, Appendices to Report Nos. 1 to 18, pp. 79-513.  
 PARTIES. Distribution of, p. 2; Appendix No. 1, pp. 81-86.  
 PARTY EXPENSES. Reference to, pp. 8, 9, 10.

- PATTERSON** (steamer). Use of in Section XII, pp. 65, 66; transfer from Atlantic to Pacific coast, pp. 74, 75; reference to reports on, by Captain Chester and Lieutenant Clover, p. 74; Appendix No. 5, p. 121.
- PAY OF FIELD OFFICERS.** Reference in explanation of estimates, p. 9; in estimates, p. 11.
- PAY OF OFFICE FORCE.** Reference to, in estimates, p. 11.
- PAYNTER, HON. JOHN H., ATTORNEY-GENERAL OF DELAWARE,** p. 33.
- PECHO POINT, SAN LUIS OBISPO BAY,** p. 54.
- PECONIC, LONG ISLAND,** p. 22.
- PEIRCE, C. S., ASSISTANT.** Gravity determinations at Fortress Monroe, p. 37; at Smithsonian Institution, p. 38; at Key West, Fla., p. 46; charge of Office of Weights and Measures, p. 37; memoirs read before American Metrological Society and National Academy of Sciences; conference with manufacturers of electrical instruments and testimony before Congressional committee, p. 38; Appendix No. 1, pp. 83, 84.
- PELICAN ISLAND, MOBILE BAY,** p. 49.
- PENOBSCOT BAY.** Reference to discussion of tides in, p. 7.
- PENNSYLVANIA.** Progress of work in, p. 3; reconnaissance and triangulation in the eastern portion of, p. 31; reconnaissance in western half of, p. 32; special triangulation for the city of Philadelphia, p. 32; magnetic observations at Philadelphia, p. 34.
- PERIL STRAIT, ALASKA,** p. 5.
- PERKINS, F. W., ASSISTANT.** Determination of points for State survey of Massachusetts, p. 19; special triangulation of Delaware River from Petty's Island to Poquessink Creek, p. 34; triangulation and topography of the coast of Louisiana from Côté Blanche to the westward, p. 50; improvement of lights used as night signals, p. 50; Appendix No. 1, pp. 81, 83, 84.
- PETERS, G. H., LIEUTENANT, U. S. N.,** p. 14.
- PETERSEN A.** Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- PETROFF, IVAN, DEPUTY COLLECTOR OF CUSTOMS, SAINT PAUL, KADIAK ISLAND, ALASKA,** p. 66.
- PETTY'S ISLAND,** p. 34.
- PHILADELPHIA.** Special triangulation for, p. 32; location of port-warden lines for harbor of, p. 33; magnetic observations at, p. 35; suboffice at, pp. 72, 73.
- PHYSICAL HYDROGRAPHY OF DELAWARE BAY AND RIVER,** pp. 32, 34.
- PHYSICAL HYDROGRAPHY OF NEW YORK BAY AND HARBOR.** Development of plans for the study of, pp. 28-30.
- PHOTOLITHOGRAPHY.** Sheets published by, p. 5; Appendix No. 4, pp. 95, 96.
- PIEDRAS BLANCAS, CAL.,** pp. 53, 55.
- PILLSBURY, J. E., LIEUTENANT, U. S. N.,** Reference to, p. 14; hydrographic examinations off the coasts of Maine, New Hampshire and Massachusetts, p. 17; takes command of the Blake, p. 20; deep-sea soundings and current work off the Florida coast, pp. 44; 46; invention of current meter, p. 44; service rendered the Alamo, p. 46; see Appendix No. 1, pp. 81, 84; Appendix No. 5, pp. 119, 122.
- PILLAR POINT, STRAIT OF FUCA,** p. 64.
- PILOT PEAK, UTAH,** p. 71.
- PINE HILL, GIRARD COLLEGE,** p. 32.
- PINEY MOUNTAIN, PA.,** p. 31.
- PLEASANT HARBOR, HOOD'S CANAL, WASH.,** p. 61.
- PLEASANT RIVER, ME.** Hydrographic surveys in, pp. 15, 16.
- PLEASANT SPRINGS, WIS.,** p. 69.
- POINT CONCEPCION, CAL.,** pp. 53, 54.
- POINT ISABEL,** pp. 51, 52.
- POINT JUDITH, R. I.** Shoaling near, p. 20.
- PONY-SIMPSON, line of triangulation,** p. 60.
- POQUESSINK CREEK, DELAWARE RIVER,** p. 34.
- PORTER, DR. J. G.** Resignation referred to, Appendix No. 4, pp. 95, 99, 100.
- PORT ANGELOS, STRAIT OF FUCA.** Anchorage in, p. 64.
- PORTLAND, OREG.,** p. 60.
- PORTSIMPSON, BRITISH COLUMBIA.** Magnetic observations at, p. 66.
- PORT SAN JUAN,** p. 63.
- POSSESSION STRAIT AND SOUND, WASH.** Triangulation and topography of, p. 62; tidal currents in, p. 62.
- POTATO HILL, VT.,** p. 18.
- PRATT, J. F., ASSISTANT.** Triangulation and topography of Possession Sound, p. 62; reconnaissance for triangulation of the Strait of Fuca, pp. 63, 64; Appendix No. 1, p. 85; Appendix No. 5, p. 121.
- PRESTON E. D., SUBASSISTANT.** Determination of longitudes in Arkansas, pp. 49, 50; in Texas, p. 51; reference to services in 1883 and 1884, p. 76; Appendix No. 1, p. 84.
- PRIMARY TRIANGULATION NEAR THE THIRTY-NINTH PARALLEL.** Reference to, p. 2; extension from West Virginia into Kentucky and Ohio, pp. 41, 42; reconnaissance for, in Ohio, pp. 66, 67; eastward across Illinois, p. 68; westward in Missouri and Kansas, pp. 69, 70; in Utah, pp. 70, 71.
- PRIMARY TRIANGULATION OF THE COAST OF CALIFORNIA,** pp. 53, 54, 55-57; reference to, in estimates, p. 10.
- PRINTING ROOM, IMPROVEMENTS MADE IN,** p. 5; Appendix No. 4, pp. 95, 107.
- PRODUCE EXCHANGE, NEW YORK CITY,** p. 72.
- PROGRESS MADE IN CONNECTING THE LINE OF TRANS-CONTINENTAL LEVELING WITH A POINT ON THE GULF COAST,** pp. 68, 69.
- PROJECTIONS MADE, NUMBER OF,** p. 5.
- PROJECTION TABLES.** Reference to preparation of, pp. 14, 75; to completion and publication of, Appendix No. 4, p. 97.
- PROSPECT HARBOR, ME.** Topographical survey in the vicinity of, p. 16.
- PROSPECT POINT-WHORTLEBERRY ISLAND,** line of triangulation, p. 26.
- PROVIDENCE, R. I.** Magnetic observations at, p. 20; tidal observations at, p. 21; Appendix No. 4, p. 101.
- PUBLICATIONS RECEIVED AND DISTRIBUTED.** Appendix No. 4, p. 111.
- PUBLISHING OBSERVATIONS.** Reference to, in estimates, p. 13.
- PUGET SOUND.** Soundings in vicinity of, p. 64.
- PULPIT HARBOR, NORTH HAVEN ISLAND, ME.** Tidal observations at, p. 17; Appendix No. 4, pp. 101, 102.
- PULPIT ROCK, PA.,** p. 31.
- PUNTA RASA, FLA.,** p. 46.
- PURCELL J. L., ENSIGN, U. S. N.** Services in Section X, p. 55.
- Q.**
- QUATSAP STATION, WASH. TER.,** p. 61.
- QUICK (schooner).** Use of in Section VI, p. 46; laid up at, p. 47; Appendix No. 5, p. 120.
- QUILCINE HARBOR, HOOD'S CANAL,** p. 61.
- QUIMBY, PROF. E. T., ACTING ASSISTANT.** Triangulation in the State of New Hampshire, pp. 17, 18; Appendix No. 1, p. 81.
- QUIXES LEDGE,** p. 25.
- QUODDY HEAD, ME.** Reference to, in estimates, p. 10.
- R.**
- RACY POINT, FLA.,** p. 43.
- READY (schooner).** Use in Section I, p. 21; in Section II, p. 22; in Section III, p. 41; in Section VI, p. 43; Appendix No. 5, pp. 118, 119.
- RECONNAISSANCE IN THE SOUTHERN PART OF THE STATE OF NEW JERSEY,** p. 30.
- RECONNAISSANCE IN THE EASTERN PORTION OF THE STATE OF PENNSYLVANIA,** p. 31.
- RECONNAISSANCE IN THE WESTERN HALF OF THE STATE OF PENNSYLVANIA,** p. 32.
- RECONNAISSANCE ON THE NEW JERSEY COAST,** p. 35.
- RECONNAISSANCE FOR THE CONNECTION OF THE TRIANGULATION OF THE GULF COAST WITH THAT ALONG THE BLUE RIDGE,** p. 48.
- RECONNAISSANCE OF THE OLYMPIC MOUNTAINS,** p. 61.
- RECONNAISSANCE FOR THE TRIANGULATION OF THE STRAIT OF FUCA,** pp. 62-64.
- RECONNAISSANCE FOR EXTENDING THE PRIMARY TRIANGULATION NEAR THE THIRTY-NINTH PARALLEL FROM WEST VIRGINIA INTO KENTUCKY AND OHIO,** pp. 66, 67.
- RECONNAISSANCE IN UTAH NEAR THE THIRTY-NINTH PARALLEL,** pp. 70, 71.

- RECORDS OF FIELD AND OFFICE WORK OF THE COAST AND GEODETIC SURVEY. Appendix No. 2, p. 88.
- RECORDS OF OBSERVATIONS WITH SELF-REGISTERING TIDE-GAUGES. AT PULPIT COVE, NORTH HAVEN ISLAND, PENOBSCOT BAY, p. 17; at Governor's Island, New York Harbor, p. 30; at Sandy Hook, N. J., p. 30.
- RED HILL STATION, p. 56.
- RED HOOK, pp. 26, 28.
- REED, T. D., CUSTODIAN OF ARCHIVES OF COAST AND GEODETIC SURVEY OFFICE. Appendix No. 4, pp. 112-114.
- RENT OF OFFICE BUILDINGS. Reference to, in estimates, p. 13.
- RE-ORGANIZATION OF BUREAU. Reference to, p. 8.
- REPAIRS AND MAINTENANCE OF VESSELS. Reference to in estimates, p. 13; Appendix No. 5, pp. 121, 122.
- REPORTS IN REGARD TO THE SUBOFFICES AT BOSTON, NEW YORK, AND PHILADELPHIA, p. 72.
- REPORT OF THE ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR THE FISCAL YEAR ENDING JUNE 30, 1885, AND INCLUDING REPORTS FROM ALL THE DIVISIONS OF THE COAST AND GEODETIC SURVEY OFFICE, Appendix No. 4, pp. 95-116.
- REPORT OF THE HYDROGRAPHIC INSPECTOR FOR THE FISCAL YEAR ENDING JUNE 30, 1885, Appendix No. 5, pp. 117-128.
- RESEARCH (schooner). Laid up, Appendix No. 5, p. 120.
- RESULTS DEDUCED FROM THE GEODETIC CONNECTION OF THE YOLO BASE LINE WITH THE PRIMARY TRIANGULATION OF CALIFORNIA. Also a reduction and adjustment of the Davidson quadrilaterals, Appendix No. 9, pp. 441-467.
- RE-SURVEY OF DELAWARE BAY. Advance of, pp. 2, 35, 36, 37; reference to, in estimates, p. 10.
- RE-SURVEY OF LONG ISLAND SOUND. Advance of, pp. 2, 3, 21, 22, 23, 24, 25, 26.
- RE-SURVEY OF NEW YORK BAY AND HARBOR. Advance of, pp. 2, 3, 25, 26, 27, 28.
- RE-SURVEY OF SAN FRANCISCO BAY. Reference to, p. 8; in estimates, p. 11.
- RE-SURVEY OF SAN PABLO BAY. Reference to, in estimates, p. 11.
- RE-SURVEY OF SUISUN BAY. Reference to, in estimates, p. 11.
- RE-SURVEY OF CARQUINEZ STRAIT. Reference to, in estimates, p. 11.
- RHODE ISLAND. Geographical positions in, p. 6; hydrographic examinations off the coast of, pp. 19, 20; magnetic observations p. 20; tidal observations, p. 21; Appendix No. 8.
- RICE CREEK, SAINT JOHN'S RIVER, FLA., p. 44.
- RICHARDS, CAPT. R. N., p. 63.
- RIDGEWAY, N. J., p. 30.
- RIPLEY, C. S., ENSIGN, U. S. N. Services in Section II, p. 27.
- ROBERT, COL. HENRY M., U. S. ENGINEERS, p. 34.
- ROCKAWAY BEACH. Topographical re-survey of shore-lines of, p. 27.
- ROCKS IN MISSION BAY, p. 57.
- ROCKWELL, CLEVELAND, ASSISTANT. Topographical survey in the Columbia and Willamette Rivers; hydrography of Willamette River, pp. 4, 60, 61; Appendix No. 1, p. 85.
- ROCKWELL, C. O. Miscellaneous Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 111.
- ROCKY BUTTE STATION, pp. 53, 54.
- ROCKY MOUND STATION, p. 56.
- ROCKY POINT, LONG ISLAND. Hydrographic examinations off, p. 22.
- RODGERS, A. F., ASSISTANT. Coast-line survey between San Juan, Capistrano, and Newport Bay, Cal., p. 52; temporary charge of suboffice at San Francisco, p. 52; Appendix No. 1, p. 84.
- ROGERS, A. G., ENSIGN, U. S. N. Services in Section II, p. 28.
- ROGUE ISLAND, p. 15.
- ROUND TOP, PA., p. 31.
- RUEBSAM, A. C. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- SABINE PASS, LA. Hydrographic survey from, to the eastward, pp. 50, 51.
- SABINE BANK, GULF OF MEXICO. Development of, p. 5.
- SABINE LAKE, TEX., Appendix No. 5, p. 119.
- SACRAMENTO RIVER, CAL. Examination of mouth of, reference to, p. 9; in estimates, p. 11.
- SAEGMULLER, G. N., Appendix No. 4, pp. 96, 97, 115.
- SAINT GEORGE'S BANK. A plea for a light on, p. 7; Appendix No. 11, pp. 483-485.
- SAINT JOHN'S RIVER, FLA. Triangulation, shore-line topography, and hydrography of, p. 43; Appendix No. 5, p. 119.
- SAINT JOSEPH'S BAY, FLA. Reference to, in estimates, p. 10.
- SAINT PAUL, KADIAK ISLAND, ALASKA. Tidal observations at, p. 66; Appendix No. 4, pp. 96, 102.
- SALMON BANK, STRAIT OF FUCA, p. 64.
- SALT LAKE CITY, UTAH. Magnetic observations at, p. 71.
- SANDY HOOK, N. J. Topographical re-survey of, p. 30; reference to discussion of tides at, p. 7; tidal observations at, p. 30; Appendix No. 4, pp. 101, 102.
- SANDWICH ISLANDS. Tidal observations at Honolulu, p. 75.
- SAN FRANCISCO, CAL. Suboffice at, p. 57; magnetic observations at, p. 57; examination of bar, reference to, p. 9; in estimates, p. 11; changes in, pp. 2, 55, 57, 58.
- SAN FRANCISCO BAY. Re-survey of, reference to, p. 8; in estimates, p. 11; tide-gauge record in, p. 58.
- SAN JOAQUIN RIVER. Examination of mouth of, reference to, p. 9; in estimates, p. 11.
- SAN JUAN CAPISTRANO, CAL. Connection made with work at Newport Bay, p. 52.
- SAN MATEO, FLA., p. 43.
- SAN MATEO, CAL., p. 52.
- SAN PABLO BAY, CAL. Re-survey of; reference to, in estimates, p. 11.
- SUISUN BAY, CAL. Reference to, in estimates, p. 11; hydrographic survey in vicinity of, pp. 54, 55.
- SARGENT, F., TIDAL OBSERVER AT SAINT PAUL, KADIAK ISLAND, ALASKA, p. 66; Appendix No. 1, p. 85; Appendix No. 4, p. 102.
- SAUCELITO, CAL. Tidal observations at, p. 58; earthquake waves recorded at, p. 75; Appendix No. 4, pp. 96, 102.
- SAYBROOK, CONN., p. 22.
- SCHOTT, CHARLES A., ASSISTANT. Magnetic observations at station on Capitol Hill, Washington, D. C., p. 38; reference to paper on magnetic variation, p. 75; see Appendix No. 1, p. 83; Appendix No. 4, pp. 95, 97, 99-101.
- SCIENTIFIC WORK. Special, pp. 6, 7.
- SCIOTO STATION, SCIOTO COUNTY, OHIO, p. 42.
- SCIOTO STATION, UTAH, p. 71.
- SCOFIELD, H. C., CITY ENGINEER, BRIDGEPORT, CONN., p. 30.
- SCORESBY (schooner). Use of in Section II, p. 28; Appendix No. 5, p. 120.
- SEABECK HARBOR, HOOD'S CANAL, WASH., p. 61.
- SEA CLIFF, HEMPSTEAD HARBOR, LONG ISLAND, p. 26.
- SEAL ROCK, R. I. Ledge developed near, p. 5.
- SECULAR VARIATION AND GEOGRAPHICAL DISTRIBUTION OF THE MAGNETIC DIP, AND INTENSITY IN THE UNITED STATES, p. 6; reference to, pp. 75, 95; Appendix No. 6, pp. 129-274.
- SECURITY BAY, CHATHAM STRAIT, ALASKA. Rock discovered in, p. 5.
- SELF-REGISTERING TIDE-GAUGE RECORD KEPT UP AT SAUCELITO, SAN FRANCISCO BAY, p. 58.
- SELMA, ALA., p. 48.
- SENTELLER, LOUIS A., ASSISTANT. Topography of Umpqua River, Oreg., pp. 59, 60; Appendix No. 1, p. 85.
- SERIES OF OBSERVATIONS CONTINUED AT THE MAGNETIC SELF-REGISTERING RECORD STATION AT LOS ANGELES, CAL., pp. 52, 53.
- SHALER, PROF. N. S. Harvard College, Cambridge, Mass., p. 18.
- SHAMONG, N. J., p. 30.
- SHELTER ISLAND, LONG ISLAND SOUND, p. 21.
- SHEPHEARD, F. W., TIDAL OBSERVER AT SANDY HOOK, N. J., p. 30; Appendix No. 4, p. 102.
- SHERMAN, F. H., ENSIGN, U. S. N. Services in Section II, pp. 25, 27; Appendix No. 1, p. 82.
- SHIDY, L. P. Tidal Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 103.

- SHIP AND SWASH CHANNELS, NEW YORK HARBOR, Appendix No. 5, p. 118.
- SILLIMAN (schooner). Laid up, Appendix No. 5, p. 120.
- SHORE LINE TOPOGRAPHY OF SAINT JOHN'S RIVER, FLA., BETWEEN RACY POINT AND PALATKA, p. 43, 44.
- SIMPSON, EDWARD, ENSIGN, U. S. N. Services in Section I, pp. 19, 20; in Section VI, p. 45; Appendix No. 1, pp. 81, 84.
- SIMS STATION, IND., p. 67.
- SINCLAIR, C. H., ASSISTANT. Trigonometric work in and around the city of Philadelphia, p. 32; determination of longitudes in Arkansas and Texas, pp. 49, 50, 51; in Missouri, p. 70; in office of assistant in charge, p. 76; Appendix No. 1, pp. 83, 84, 85; Appendix No. 4, p. 98.
- SIPE, E. H. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- SITKA HARBOR, ALASKA, p. 5.
- SIX-MILE REEF, LONG ISLAND SOUND, p. 5, 24.
- SLAUGHTER CREEK, DELAWARE BAY, p. 36.
- SLIP POINT-SHERRINGHAM POINT, line of triangulation, p. 63.
- SMEDLEY, SAMUEL L., CITY ENGINEER OF PHILADELPHIA, pp. 32, 34.
- SMITH, EDWIN, ASSISTANT. Magnetic determinations at Philadelphia, p. 34; longitude determinations in Arkansas and Texas, pp. 49, 50, 51; in Missouri, p. 70; Appendix No. 1, pp. 83, 84, 86.
- SMITH, PROF. EUGENE A., STATE GEOLOGIST OF ALABAMA, p. 48.
- SMITH, JAMES L. Printing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- SMITHSONIAN INSTITUTION. Gravity determinations at, p. 38.
- SMOOT, JOHN H., CLERK TO ENGRAVING DIVISION, COAST AND GEODETIC SURVEY OFFICE, Appendix No. 4, pp. 96, 107.
- SNOHOMISH RIVER, WASH., p. 62.
- SNOW, A. S., LIEUTENANT COMMANDER U. S. N. Hydrographic Survey in Strait of Fuca, pp. 63, 64, 65; Appendix No. 1, p. 85; Appendix No. 5, p. 121.
- SNYDER, PROF. H. B., p. 34.
- SOMERS COVE LIGHT, p. 41.
- SOMMER, E. J. Drawing Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 104.
- SOUTH CAROLINA. Reference to, in estimates, p. 10; hydrographic survey in Stono and Wadmelaw Rivers, pp. 42, 43.
- SOUTHERN CALIFORNIA. Reference to, in estimates, p. 10.
- SOUTH NORWALK, CONN., p. 25.
- SOUTHOLD, LONG ISLAND, p. 21.
- SOUTHWEST LEDGE, LONG ISLAND SOUND, p. 22.
- SOUTHWEST LEDGE LIGHT, p. 25.
- SPAULDING, J. G., TIDAL OBSERVER AT PULPIT COVE, NORTH HAVEN ISLAND, PENOBSCOT BAY, p. 17; Appendix No. 1, p. 81; Appendix No. 4, pp. 102, 103.
- SPECIAL OPERATIONS, pp. 4, 71-75.
- SPECIAL SCIENTIFIC WORK, pp. 6, 7.
- SPECIAL TRIANGULATION OF DELAWARE RIVER FROM PETTY'S ISLAND TO POQUESSINK CREEK, p. 34.
- SPECIAL TRIANGULATION FOR THE CITY OF PHILADELPHIA, p. 32.
- SPRING HILL, ALA., p. 48.
- STAMFORD HARBOR LIGHT, CONN., p. 3.
- STANSBURY, P. R., CLERK TO COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, Appendix No. 4, p. 101.
- STATE SURVEYS. Furnishing points for, reference to, pp. 2, 8; in estimates, p. 11; State of Massachusetts, p. 18.
- STATIONS OCCUPIED FOR CONTINUING THE TRIANGULATION IN THE STATE OF VERMONT, p. 18.
- STATISTICS OF FIELD AND OFFICE WORK OF THE COAST AND GEODETIC SURVEY FOR THE FISCAL YEAR ENDING JUNE 30, 1885, Appendix No. 2, pp. 87, 88.
- STOCKTON, HON. JOHN P., ATTORNEY-GENERAL FOR NEW JERSEY, p. 33.
- STONO RIVER, S. C., pp. 42, 43; Appendix No. 5, p. 119.
- STRAIT OF CARQUINEZ. Re-survey of, reference to, in estimates, p. 11.
- STRAIT OF FUCA. Reconnaissance for triangulation of, p. 63; hydrographic survey in, p. 64; currents in, pp. 64, 65; Appendix No. 5, p. 121.
- STRATFORD, CONN. Topographical re-survey near, pp. 22, 23.
- STRIPED PEAK, WASH., p. 64.
- SUBOFFICES, pp. 4, 57, 72, 73.
- SUBSISTENCE FOR NAVAL OFFICERS IN COAST SURVEY SERVICE. Reference to, in estimates, p. 10.
- SUISUN BAY, CAL. Reference to, in estimates, p. 11.
- SULLIVAN, J. A., p. 33.
- SUMMIT STATION, IND., p. 68.
- SUPPLEMENTARY TOPOGRAPHICAL SURVEY BETWEEN NORFOLK AND THE OCEAN SHORE, p. 41.
- SURVEY OF THE COAST OF CALIFORNIA CONTINUED FROM MORO BAY WESTWARD, p. 54.
- SURVEY OF THE COAST LINE CONNECTING THE WORK AT SAN JUAN CAPISTRANO WITH THAT AT NEWPORT BAY, CAL., p. 52.
- SURVEY OF THE U. S. ENGINEERS. Connection made with pp. 68 and 69.
- SUPERINTENDENT HAWAIIAN GOVERNMENT SURVEY, pp. 57, 75; Appendix No. 1, p. 86.
- SUPERINTENDENT COAST AND GEODETIC SURVEY. Traveling expenses of, reference to, in estimates, p. 11.
- SWASH CHANNEL, NEW YORK HARBOR, Appendix No. 5, p. 118.
- SWATARA GAP, LEBANON COUNTY, PA., p. 31.
- SWITCH STATION, IND., p. 67.

## T.

- TANEY, E. L., AID. Re-survey of Sandy Hook, N. J., p. 30; services in Section II, p. 36; in Section VIII, p. 50; Appendix No. 1, pp. 82, 83, 84.
- TARRY-NOT (steam launch), p. 62.
- TATHAM-PUBLIC, p. 36.
- TATOOSH ISLAND, STRAIT OF FUCA, p. 63.
- TAUSSIG, E. D., LIEUTENANT, U. S. N. Hydrographic surveys on coast of California, pp. 54, 55, 58; Appendix No. 1, p. 85; Appendix No. 5, p. 121.
- TAYLOR, HENRY R., p. 15; Appendix No. 1, p. 81.
- TENNESSEE. Triangulation in, pp. 66, 67.
- TERRY, CARLISLE, AID. Magnetic observations at Los Angeles, Cal., pp. 52, 53; Appendix No. 1, p. 84.
- TERRY POINT, LONG ISLAND. Hydrographic work off, p. 32.
- TEXARKANA, ARK. Determination of longitude at, p. 49.
- TEXAS. Reference to, in estimates, p. 10; determination of longitude at Brownsville, p. 51; triangulation and wire measurement between Point Isabel and Brownsville, pp. 51, 52.
- THE GEOGRAPHICAL DISTRIBUTION AND SECULAR VARIATION OF THE MAGNETIC DIP AND INTENSITY IN THE UNITED STATES, Appendix No. 6, pp. 129-274.
- THOM, W. A., ENSIGN, U. S. N. Services in Section VI, p. 45; Appendix No. 1, p. 84.
- THOMAS, E. B., LIEUTENANT-COMMANDER, U. S. N. Services in New York Harbor, Appendix No. 5, p. 118.
- THOMAS, M. Tidal Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 103.
- THOMPSON, J. G. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- THOMPSON, L. B., TIDAL OBSERVER AT NEW HAVEN, CONN., Appendix No. 4, p. 102.
- THOMPSON, W. A. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- TIDAL DIVISION. Report from, Appendix No. 4, pp. 101-103.
- TIDAL OBSERVATIONS. Reference to, in estimates, pp. 9, 10; on coast of Maine, p. 17; at Providence, R. I., p. 21; at New Haven Breakwater, p. 25; at Governor's Island, New York Harbor, pp. 7, 30; at Sandy Hook, N. J., pp. 7, 30; at Saucelito, Cal., p. 58; at Saint Paul, Kodiak Island, Alaska, p. 66; at Honolulu, Sandwich Islands, p. 75; Fort Mifflin, Pa., Charleston, S. C., Appendix No. 4, p. 101; Fort Simpson, British Columbia, Appendix No. 4, p. 102.
- TIDE-GAUGES. Suggestions for establishing, at certain points, Appendix No. 4, p. 102.
- TIDE PREDICTOR. Use of, p. 75; Appendix No. 4, pp. 96, 103.
- TIDE TABLES. Preparation of, p. 5; Appendix No. 4, p. 103.
- TITTMANN, O. H., ASSISTANT. Reconnaissance in Pennsylvania, p. 31; for connecting the triangulation of the Gulf with that along the Blue Ridge, p. 48; Appendix No. 1, pp. 82, 84; Appendix No. 4, pp. 99, 101.

- TONGASS NARROWS SOUTHEASTERN ALASKA, p. 55.
- TOPOGRAPHICAL SURVEYS AND RESURVEYS. Of Machias Bay, entrance Machiasport, and the coast to the eastward, pp. 14, 15; of Chandler's Bay and Englishman's Bay, Me., p. 15; in vicinity of Prospect Harbor, Gouldsborough, Me., and Bar Harbor, Mount Desert Island, pp. 16, 17; of the northeastern coast of Long Island in the vicinity of Gardiner's Bay, Shelter Island, and Greenport; also of the north shore of the Sound from Darien, Conn., eastward, pp. 21, 22, 28; of the north shore of Long Island to the west of Greenport, p. 22; at the mouth of the Connecticut River, and near Milford and Stratford, on the north shore of Long Island Sound; also from Lloyd's Neck eastward on the south shore, pp. 22, 23; on the north shore of Long Island Sound in the vicinity of Madison, Guilford, and Bradford, Conn., pp. 23, 24; of the north shore of Long Island Sound westward from Frost (or Farms) Point, and including the Norwalk Islands; also the shores of East River, N. Y., pp. 25, 26; of the shore lines of Coney Island and Rockaway Beach, New York Lower Bay, p. 27; of the shores of North River, N. Y., p. 28; of Sandy Hook, N. J., p. 30; of the New Jersey shore of Delaware Bay, pp. 35, 36; of the western shore of Delaware Bay, p. 36; of the District of Columbia, pp. 38, 39; between Norfolk, Va., and the ocean shore, p. 41; of shore line of Saint John's River, Fla., from Nine Mile Point to Palatka, p. 43; of west coast of Florida from Bowditch Point to Cape Romano, pp. 46, 47; of the coast of Louisiana from Coté Blanche Bay to the westward, p. 50; of the coast of California from Moro Bay to the westward, p. 54; of the Umpquah River, Oreg., pp. 59, 60; of the Columbia and Willamette Rivers, pp. 60, 61; of Hood's Canal, Wash. Terr., p. 61; of Possession Strait and Sound, Wash. Terr., p. 62.
- TOPOGRAPHIC (AND HYDROGRAPHIC) SURVEYS. List of sheets received and deposited in the archives of the Coast and Geodetic Survey, Appendix No. 4, p. 113.
- TOPOGRAPHY. Statistics of, Appendix No. 2, p. 87; Appendix No. 4, p. 113.
- TORO MOUNTAIN, CAL., p. 56.
- TORONTO, CANADA. Examination of methods employed at the Magnetic Observatory at, pp. 4, 71, 72.
- TORREY, E. E., pp. 41, 42.
- TOWNSHEND'S INLET, N. J., p. 35.
- TRANSCONTINENTAL GEODETIC WORK, pp. 2, 3, 4, 41, 42, 66, 67, 68, 69, 70, 71, reference to, in estimates, pp. 10, 11.
- TRASK HILL, N. H., p. 18.
- TRAVELING EXPENSES OF NAVAL OFFICERS ATTACHED TO COAST AND GEODETIC SURVEY. Reference to, in estimates, p. 10; of Superintendent of Coast and Geodetic Survey, p. 11.
- TRESCOT, E. A. Computing Division, Coast and Geodetic Survey, Appendix No. 4, pp. 99, 101.
- TRADD STATION, p. 41.
- TRIANGULATION. Of the State of New Hampshire, pp. 17, 18; of State of Vermont, p. 18; in the western part of Long Island Sound from Loyd's Neck toward New Rochelle, p. 20; for the resurvey of New York Lower Bay, p. 27; in southern part of State of New Jersey, pp. 30, 31; in eastern portion of State of Pennsylvania, p. 31; for city of Philadelphia, p. 32; of Delaware River from Petty's Island to Poquessink Creek, p. 34; on New Jersey coast, p. 35; near the thirty-ninth parallel, from West Virginia into Kentucky and Ohio, pp. 41, 42; of the shore of Saint John's River, Fla., from Nine Mile Point to Palatka, p. 43; of the coast of Louisiana from Coté Blanche Bay to the westward, p. 50; between Point Isabel and Brownsville, Texas, pp. 51, 52; of the coast line between San Juan Capistrano and Newport Bay, Cal., p. 52; of the coast of California, north of Point Conception, pp. 53, 54; from Moro Bay westward, 54, 55; of the Umpquah River, Oreg., pp. 59, 60; of the State of Tennessee, pp. 66, 67; of the State of Ohio, p. 67; of the State of Indiana, p. 67; near the thirty-ninth parallel eastward across the State of Illinois, p. 68; of the State of Wisconsin, p. 69; in Missouri and Kansas, p. 69; near the thirty-ninth parallel in Utah, pp. 70, 71.
- TRIANGULATION CONNECTED WITH THAT OF THE U. S. LAKE SURVEY, pp. 68, 69.
- TRIGONOMETRICAL OPERATIONS IN AID OF A TOPOGRAPHICAL SURVEY OF THE STATE OF MASSACHUSETTS, pp. 2, 3, 18.
- TRUXTUN, WM., ENSIGN, U. S. N. Services in Section I, p. 20; in Section VI, p. 45; Appendix No. 1, pp. 81, 84.
- TURNER, J. H., AID. Services in Section I, p. 15; in Section VI, p. 47; Appendix No. 1, pp. 81, 84.
- TURNBULL, C. B. Tidal Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 103.
- TUSSAY MOUNTAIN, PA., p. 32.
- U.
- UMPQUAH RIVER, OREG. Triangulation and topography of, pp. 4, 59, 60.
- UNITED STATES. Discussion of secular variation and geographical distribution of magnetic dip and intensity in, pp. 4, 6; Appendix No. 6, pp. 129-274; reference to map of, Appendix No. 4, p. 97.
- UNITED STATES COMMISSION ON THE IMPROVEMENT OF THE NAVIGATION OF THE DELAWARE, pp. 7, 33, 34.
- UNITED STATES COAST AND GEODETIC SURVEY OFFICE, pp. 75, 76.
- UNITED STATES ENGINEER CORPS. Connections made with triangulation of, pp. 68, 69; electrotype plates made for, p. 5; Appendix No. 4, p. 98; tidal observations at Fort Mifflin, Pa., directed by officers of, Appendix No. 4, p. 102; at Charleston, S. C., Appendix No. 4, p. 102.
- UNITED STATES LAKE SURVEY. Connection made with triangulation of, pp. 68, 69.
- USSAL ROCK, CAL., p. 59.
- UTAH. Reconnaissance and triangulation in, pp. 4, 70, 71; magnetic observations, in, p. 71.
- UNION CITY, WASH. TERR., p. 61.
- V.
- VAN ORDEN, C. H., SUBASSISTANT. Determination of points for Massachusetts State survey, pp. 18, 19; services in Section II, p. 24; special triangulation, for the city of Philadelphia, p. 32; in Delaware River, p. 34; Appendix No. 1, pp. 81, 82, 83.
- VANCOUVER ISLAND, BRITISH COLUMBIA, p. 63.
- VERIFICATION AND CORRECTION OF REDUCED DRAWINGS OF HYDROGRAPHY FOR THE FISCAL YEAR ENDING JUNE 30, 1885; Appendix No. 5, p. 124.
- VERMILLION BAY, LA., p. 50.
- VERMONT. Geodetic operations in, pp. 3, 18.
- VESSELS. Repairs and maintenance of, pp. 10, 13; Appendix No. 5, pp. 121, 122, 127.
- VICTORIA, BRITISH COLUMBIA, pp. 62, 63.
- VIERBUCHEN, P. Instrument Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 115.
- VILLA RIDGE, ILL., p. 60.
- VINAL, W. I., ASSISTANT. Services in Section II, pp. 21, 22; Appendix No. 1, p. 82.
- VINES, RICHARD, p. 15.
- VINEYARD SOUND. Ledges and shoals developed, pp. 2, 5, 19, 20; Appendix No. 5, p. 117.
- VIRGINIA. Gravity determinations at Fortress Monroe, p. 37; lines of leveling run from Ashland to Fortress Monroe, pp. 39, 40; points determined on boundary line between Maryland and, pp. 40, 41; hydrographic examination off Cape Henry, p. 41; supplementary topographical survey between Norfolk and the ocean shore, p. 41.
- VOYAGE OF THE NEW STEAMER C. P. PATTERSON FROM THE ATLANTIC TO THE PACIFIC COAST, pp. 74, 75; Appendix No. 5, p. 121.
- W.
- WADMELAW, S. C., pp. 42, 43; Appendix No. 5, p. 119.
- WAINWRIGHT, D. B., ASSISTANT. Topographical re-survey of the shores of North River, N. Y., from Red Hook and Craven's Point to Fifty-ninth street and opposite shore, p. 28; services in survey of District of Columbia, p. 39; Appendix No. 1, pp. 82, 83.
- WALKER, GENERAL FRANCIS A., p. 18.
- WARRBURTON, EDGAR T., ASSISTANT ENGINEER, U. S. N. Services in Section XI, p. 65.
- WARD'S COVE, ALASKA, p. 65.
- WARWICK, R. I. Depth of water near, p. 20.
- WASHINGTON, D. C. Magnetic observations at, pp. 34, 38; gravity determinations at, pp. 37, 38; line of levels between Capitol bench-mark and bench-mark at Aqueduct Bridge, pp. 39, 40.

- WASHINGTON TERRITORY. Reference to, in estimates, p. 10; topography and hydrography of Hood's Canal, pp. 61, 62; triangulation and topography of Possession Strait and Sound, p. 62; reconnaissance of the Olympic Mountains, p. 61; characteristics of hydrography of the Strait of Fuca, p. 64.
- WASSERBACH, T. Engraving Division, Coast and Geodetic Survey Office, Appendix No. 4, p. 107.
- WATER DEPARTMENT OF PHILADELPHIA, p. 73.
- WATERS, J. S., ENSIGN, U. S. N. Services in Section II, p. 25; in Section VIII, p. 51; Appendix No. 1, pp. 82, 84.
- WEBSTER, GEORGE S., Courtesies acknowledged, p. 34.
- WEEHAWKEN FERRY, p. 28.
- WEIGHTS AND MEASURES, OFFICE OF CONSTRUCTION OF. Report from, Appendix No. 4, pp. 115, 116.
- WEIR, J. B., ASSISTANT. Lines of levels run between Ashland and Fortress Monroe, Va., pp. 39, 40; to connect the benchmark at Washington Aqueduct Bridge with Capitol bench-mark, p. 40; to connect the transcontinental leveling with a point on the Gulf Coast, pp. 68, 69.
- WELCH (OR CEDAR) POINT. North shore of Long Island Sound, pp. 24, 28.
- WELKER, P. A., AID. Services in Section X, p. 54; Appendix No. 1, p. 85.
- WERLICH, P. J., ENSIGN, U. S. N. Services in Section I, p. 20; in Section VI, p. 45; Appendix No. 1, pp. 81, 84.
- WESTDAHL, F., DRAUGHTSMAN, SUBOFFICE AT SAN FRANCISCO, CAL., p. 57.
- WEST SAND ISLAND, MOBILE BAY, p. 49.
- WEST VIRGINIA. Extension of primary triangulation near the thirty-ninth parallel, pp. 41, 42; reconnaissance for, p. 66.
- WHIDBEY ISLAND, STRAIT OF FUCA, pp. 63, 64.
- WHITE ROCK, pp. 58, 59.
- WHITE, GEO. B., CAPTAIN, U. S. N., CHAIRMAN ADVISORY COMMISSION TO THE HARBOR COMMISSION OF PHILADELPHIA, p. 34.
- WHITE, W. P., ENSIGN, U. S. N. Services in Section XI, p. 65; Appendix No. 1, p. 85.
- WHITING, ME., p. 15.
- WHITING, HENRY L., ASSISTANT. Trigonometrical operations in aid of State survey of Massachusetts, pp. 18, 19; Appendix No. 1, p. 81.
- WIGGINS PASS, FLA., p. 46.
- WILKES-BARRE, PA., p. 31.
- WILSON, RICHARD C., VOLUNTEER AID, p. 50; Appendix No. 1, p. 84.
- WILLAMETTE RIVER. Reference to, in estimates, p. 10; topographic and hydrographic survey of, pp. 60, 61.
- WILLENBUCHER, E., HYDROGRAPHIC DRAUGHTSMAN, p. 14; Appendix No. 5, p. 122.
- WILLENBUCHER, W. C., HYDROGRAPHIC DRAUGHTSMAN, p. 14; Appendix No. 5, p. 122.
- WILLIAMSTOWN, N. J., p. 30.
- WILLOW BAR, COLUMBIA RIVER, p. 60.
- WINES, M. W., GENERAL OFFICE ASSISTANT. Appendix No. 4, p. 96; report Miscellaneous Division, Appendix No. 4, pp. 110-112.
- WINSTON, ISAAC, SUBASSISTANT. Services in Section X, pp. 52, 53.
- WISCONSIN. Geodetic operations in, p. 69.
- WRANGELL STRAIT, ALASKA. Dangers in, p. 5.
- WRAY STATION, LAWRENCE COUNTY, OHIO, p. 41.
- WRAY-BUENA VISTA, line of triangulation, p. 41.
- WRIGHT, E. E., ENSIGN, U. S. N. Services in Section II, p. 28.
- WRIGHT, CAPTAIN OF SCHOONER KATE GIFFORD, p. 19.
- WYVILL, E. H. In office of Hydrographic Inspector, p. 14; Appendix No. 5, p. 122.

## Y.

- YAQUINA LIGHT-HOUSE, OREGON. Geographical position determined, p. 57.
- YOLO BASE. Reference to, pp. 6, 56; see Appendix No. 9, pp. 441-467.
- YORK HARBOR, ME. Hydrographic examination, pp. 3, 5, 17.
- YOUNG, JAMES, ASSISTANT DIRECTOR MAGNETIC OBSERVATORY, TORONTO, CANADA, p. 72.
- YUKON (schooner). Use of, in Section XI, pp. 62, 63; turned over to Assistant Pratt, p. 64; Appendix No. 5, p. 121.

## Z.

- ZIWET, ALEXANDER. Computing Division, Coast and Geodetic Survey Office, Appendix No. 4, pp. 100, 101.
- ZUMBROCK, DR. A. Electrotype Division, Appendix No. 4, p. 107.



#### ERRATA.

*In Coast and Geodetic Survey Report for 1885.*

- Page 14, fifth line from bottom, insert missing letters in *including*.
- Page 24, ninth line from top, for *Oan Orden* read *Van Orden*.
- Page 27, sixth line from bottom, for *resurveg* read *resurvey*.
- Page 96, twenty-second line from top, for *of* read *at*.
- Page 472, seventeenth line from top, for *record of* read *record at*.
- Page 475, twenty-first line from top, for *from* read *for*.
- Page 476, ninth line from top, *dele*  $\Delta$ .
- Page 476, nineteenth line from top, for cBP put CBP.
- Page 476, twentieth line from top, for cAP' put CAP'.
- Page 476, twenty-first line from top, for PcB put PCB.
- Page 485, fourth line from top, for *Dart* put *Dash*.





# REPORT.

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UNITED STATES COAST AND GEODETIC SURVEY OFFICE,

*Washington, December 9, 1885.*

SIR: The report of progress made in the work of the Coast and Geodetic Survey during the fiscal year ending June 30, 1885, which I have the honor to submit herewith, as required by law, and by the regulations of the Treasury Department, is accompanied by maps showing the general advance of the survey on the Atlantic, Gulf of Mexico, and Pacific coasts and in the interior of the United States, and by an appendix exhibiting in tabular form the distribution of the several parties, the nature of their work, and the localities of their operations.

In its arrangement, this report conforms to that adopted in the recent reports of the Superintendent of this Bureau.

Part I presents general statements of progress under the several heads of field-work, office-work, discoveries, and developments, and special scientific work; it gives also an explanation of estimates and estimates in detail for the fiscal year 1886-1887.

Part II is occupied with summaries of work afloat and ashore as derived from the reports of chiefs of parties during the past fiscal year. It closes with references to the office work.

In Part III are comprised the several appendices which relate to field, office, and hydrographic details, and also those appendices which present the methods, discussions, and results of the survey in forms deemed worthy of publication.

The important step taken by the last Congress in appointing a Joint Commission of three Senators and three Representatives to "consider the present organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, with the view to secure greater efficiency and economy of administration of the public service in said Bureaus," led, as is well known, to a request from that Commission that the National Academy of Sciences would appoint a committee of its members to examine the subject, and give the Joint Commission the benefit of their special knowledge of the questions involved.

In pursuing their inquiries, the committee of the Academy requested from the Superintendent through the Secretary of the Treasury a statement of the organization and present condition of the Coast and Geodetic Survey. This statement accompanied the report of the Academy to the Commission. It embodies views deemed worthy of consideration respecting the relations of the Coast and Geodetic Survey to other Government surveys, and the methods by which the functions of these several surveys may be clearly defined, and their co-ordination well established. It has been published by the Academy in their annual report, and appears also in the Testimony before the Joint Commission (Senate Mis. Doc. No. 82, Forty-ninth Congress, first session).

The reasons urged in the last annual report for an increase in the amount appropriated for party expenses, or the cost of field work, afloat and ashore, it is gratifying to record, met with cordial support from the Department, and were recognized, though not to the full extent desired, by Congress. These reasons have lost none of their force, and I would again urge an increase in the sum available for party expenses to the amount asked for in the estimates.

## PART I.

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It is believed that during the past fiscal year the progress of the Survey in all of its branches has been commensurate with the means afforded by Congress. And although in certain sections, operations have been necessarily restricted, or temporarily suspended for want of funds, yet every effort has been made, consistently with the terms of the appropriation, to push work in important localities, as is shown in the advance towards completion of the resurveys of Long Island Sound and Delaware Bay, the beginning of the resurvey of New York Bay and Harbor, the investigation of the currents in the Gulf Stream, and of the changes in the bar at San Francisco Entrance.

The distribution of the land and water parties on the Atlantic, Gulf, and Pacific coasts and in the interior of the United States is shown in Appendix No. 1, in the geographical order heretofore observed.

In the course of the hydrographic operations, some important developments were made to which the attention of persons interested in commerce and navigation was promptly called. Statements in detail of these discoveries and developments are given in Part II; they are referred to also under a special heading in this part of the report.

Among them may be mentioned the location of rocks and rocky ledges off the coasts of Maine and Massachusetts; the location of shoals hitherto uncharted in Vineyard Sound, and the development of changes in the main ship-channel in that sound; the discovery of dangerous ledges in the course of the resurvey of Long Island Sound; the location of a dangerous rock in East River, New York, near Diamond Reef, and the development of Sabine Bank, off Sabine Pass, Gulf of Mexico.

Operations afield and afloat have been carried on within the limits or off the coasts of thirty-two States, two Territories, and in the District of Columbia. The transcontinental geodetic work intended to unite the survey of the Atlantic with that of the Pacific coast is making progress simultaneously from the Atlantic coast westward and the Pacific coast eastward, and is advancing toward a junction. Trigonometrical surveys were continued in nine States, which have made requisite provision for their own topographical and geological surveys. This work in the interior, carried on by authority of the act approved March 3, 1871, is gradually establishing an exact skeleton or framework, by means of which accurate base-lines are afforded for State surveys, by which the lines of the public land surveys can be checked in position and direction, and by which the preparation of accurate State maps is rendered possible. The practical advantages and scientific aims of such a general framework, which must of necessity be under national control, are concisely set forth in the report of Superintendent J. E. Hilgard to the National Academy of Sciences, bearing date of September 19, 1884.

### GENERAL STATEMENT OF PROGRESS.

#### I.—FIELD-WORK.

**ATLANTIC COAST.**—During the year ending June 30, 1885, the work of the Survey has included the following operations upon the coasts and within the borders of the New England States: Topography of Machias Bay entrance, Machiasport, and of the coast to the eastward continued; topographic surveys of Chandler's Bay and Englishman's Bay, and hydrographic

surveys of Narragansett River from Millbridge to Cherryfield, of Harrington River, including Flat and Back Bays, and of Pleasant River to Addison, coast of Maine; topographical survey in the vicinity of Prospect Harbor, Gouldsborough, and resurvey of Bar Harbor, Mount Desert Island, Maine; record of observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay; hydrographic examinations of York Harbor, Maine, between Marblehead Rock and Marblehead Neck, Massachusetts, and off Bass Point, Nahant, Mass.; geodetic operations continued in the States of New Hampshire and Vermont; trigonometrical operations begun in aid of a topographical survey of the State of Massachusetts; hydrographic examinations in Vineyard Sound, Narragansett Bay, and Block Island Sound; magnetic observations at Providence, R. I., and on Coaster's Harbor Island, Narragansett Bay; tidal observations with a self-registering gauge continued at Providence, R. I.; topographical resurveys at the mouth of the Connecticut River, and near Milford and Stratford, Conn. on the north shore of Long Island Sound; also, in the vicinity of Madison, Guilford, and Branford, Conn.; inshore hydrographic resurvey of the northern coast of Long Island Sound from Hammonasset Point to Welch's Point, Connecticut; tidal observations with an automatic tide-gauge at the New Haven Breakwater; continuation of the topographic resurvey of the north shore of Long Island Sound from Farms (or Frost) Point westward; triangulation extended in the western part of Long Island Sound from Stamford Harbor Light and Lloyd's Neck towards New Rochelle; and topographical resurvey of the north shore of Long Island Sound continued from Darien, Conn., towards New Rochelle, N. Y.

Upon the coasts and within the limits of the States of New York, New Jersey, Pennsylvania, and Delaware, field operations have included topographical resurveys of the northeastern coast of Long Island in the vicinity of Gardiner's Bay, Shelter Island, and Greenpoint; hydrographic work off Terry Point and Rocky and Horton's Points, Long Island; triangulation in the western part of Long Island Sound extended from Lloyd's Neck westward towards New Rochelle; topographical resurvey of the north shore of Long Island carried eastward from Lloyd's Neck; topographical resurvey of the shores of the East River, New York, and hydrographic resurvey of that river; determination of points for the resurvey of New York lower Bay; topographic resurvey of the shore lines of Coney Island and Rockaway Beach; hydrographic resurvey of New York Bay Entrance; topographic resurvey of the shores of the North River, New York; development of plans for the study of the physical hydrography of New York Bay and Harbor; tidal observations with self-registering tide-gauges at Governor's Island and at Sandy Hook; topographical resurvey of Sandy Hook; extension of reconnaissance and triangulation in the southern part of the State of New Jersey and in the eastern portion of the State of Pennsylvania; reconnaissance for triangulation in the western half of the same State; special triangulation for the city of Philadelphia; and of the Delaware River from Petty's Island to Poquessink Creek; comparison of recent with former surveys of the Delaware River and location of port-warden lines for the harbor of Philadelphia; magnetic observations at Philadelphia; determination of the position of a wreck off Barnegat; continuation of triangulation and reconnaissance on the New Jersey coast, magnetic station occupied on that coast, and topographic survey continued; continuation of the topographical resurvey of the New Jersey shore of Delaware Bay, and completion of the topographical resurvey of the opposite shore of that bay; advance towards completion of the hydrographic resurvey of lower Delaware Bay and the Entrance.

The operations of the Survey within the District of Columbia and the State of West Virginia, and upon the coasts and within the boundaries of the States of Maryland, Virginia, and South Carolina, have included gravity determinations and experimental researches at Washington, D. C., and in Virginia; annual determination of the magnetic declination, dip, and intensity at a station on Capitol Hill, Washington; continuation of the detailed topographical survey of the District of Columbia; lines of leveling of precision carried from Ashland, Va., to Fortress Monroe; also a line to connect the bench-mark near the Washington Aqueduct Bridge with the Capitol bench-mark; determination of points on the boundary line between Maryland and Virginia; hydrographic examinations off Cape Henry, Va.; supplementary topographical survey between Norfolk and the ocean shore; extension of the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio, and hydrographic survey in Stono and Wadmelow Rivers, South Carolina.

Upon the east and west coasts of Florida; in the approaches to this coast, and upon the coasts and within the limits of the Gulf States, field operations included the triangulation, shore-line topography, and hydrography of Saint John's River between Racy Point and Palatka; deep-sea soundings in Northwest Providence Channel and soundings and current observations in the Gulf Stream between Fowey Rocks and Gun Cay, Bahamas; determination of gravity at Key West; beach measure and topographical survey on the west coast of Florida from Bowditch Point to Cape Romano, and hydrography of that coast from the vicinity of Gordon's Pass to Cape Romano; continuation of reconnaissance for the connection of the triangulation of the Gulf coast with that along the Blue Ridge; hydrographic work in Mobile Bay and around the Chandeleur Islands; determination of the longitudes of Little Rock, Texarkana, and Fort Smith, Ark.; triangulation and topography of the coast of Louisiana from Coté Blanche Bay to the westward; hydrographic survey off the coast of Louisiana from Sabine Pass eastward; determination of the longitude of Brownsville, Tex., and triangulation and wire measurement between Point Isabel and Brownsville.

**PACIFIC COAST.**—Field operations upon the coasts and within the boundaries of the States of California and Oregon, of Washington Territory, and of Alaska, have included the survey of the coast line connecting the work at San Juan Capistrano with that at Newport Bay; continuation of the series of observations with magnetic self-registering instruments at Los Angeles, Cal.; continuation of the primary triangulation of the California coast north of Point Concepcion; survey of the coast westward from Moro Bay continued; hydrographic survey of the coast in the vicinity of San Simeon, Cal.; occupation of stations in continuation of the primary triangulation of the coast of California; self-registering tide-gauge record kept up at Saucelito, San Francisco Bay; hydrographic surveys on the California coast in Humboldt Bay and between Brushy Point and White Rock; continuation of the survey of the Umpquah River, Oregon, and of the topographical and hydrographical survey of the Columbia and Willamette Rivers; completion of the topography of Hood's Canal, Washington Territory, and reconnaissance of the Olympic Mountains; hydrographic surveys in Hood's Canal, and triangulation and topography of Possession Strait and Sound, Washington Territory; reconnaissance for the triangulation of the Strait of Fuca, and hydrographic survey in that strait; hydrographic surveys in Southeastern Alaska, and tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.

**INTERIOR STATES.**—In the States between the Atlantic and the Pacific coasts, field-work has included a reconnaissance for extending the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio; occupation of stations in continuation of the triangulation of the State of Tennessee; continuation of geodetic operations in the States of Ohio, Indiana, and Wisconsin; extension of the primary triangulation near the thirty-ninth parallel eastward across the State of Illinois; progress made in connecting the line of transcontinental leveling with a point on the Gulf coast; occupation of stations for continuing to the westward the primary triangulation near the thirty-ninth parallel in Missouri and Kansas; determination of the longitude of Kansas City, Mo., and continuation of the reconnaissance and transcontinental triangulation to the eastward in Utah.

**SPECIAL OPERATIONS** during the fiscal year included an examination of methods of observation and photographic processes employed at the Magnetic Observatory, Toronto, Canada; the direction of the suboffices at Boston, New York, Philadelphia, and San Francisco; the charge of the exhibit of the Coast and Geodetic Survey at the New Orleans Exposition; the transfer of the new steamer Patterson from the Atlantic to the Pacific coast, and the continuation of the automatic tide-record at a station in the Sandwich Islands.

## II.—OFFICE WORK.

In the course of office operations during the past fiscal year, the calls for information from the several Departments of the Government and requests from individuals were promptly met; special attention was given to a discussion of the secular variation and geographical distribution of the magnetic dip and intensity throughout the United States; the changes required upon the charts by the results of resurveys in important localities were deemed matters of pressing neces-

sity and were incorporated in the published editions without delay; improvements were made in the batteries used for electrotyping; an addition was built to the plate-printing room, and a new copper-plate press of large size added; the prediction tide-tables for the year 1886 were prepared for publication; fac simile copies of topographic sheets were published by photo-lithography, and improvements were begun in the instrument-room which promise increased facilities of construction and repair.

Twenty-seven new charts were published, of which 16 were photo-lithographs. For the use of the topographical and hydrographical parties, ninety-nine projections on various scales were prepared. Corrections and additions were made upon four hundred and twenty-one plates of charts, and fourteen plates of sketches. The engravings of eleven plates of charts were completed; also the engraved plates of nine new editions of charts. Forty-six basso and sixty-one alto electrotypes were made; of these numbers, thirteen bassos and fourteen altos were for the Engineer Corps, United States Army, and seven bassos and seven altos for the Hydrographic Office, Navy Department.

Distribution was made during the year of twenty-eight thousand nine hundred and five copies of charts. Of this number ten thousand seven hundred and forty were issued to meet demands from the several Executive Departments and one thousand four hundred and twenty-three to Senators and Representatives in Congress.

### III.—DISCOVERIES AND DEVELOPMENTS.

The following is a summary of dangers to navigation discovered in the course of hydrographic operations during the fiscal year. These dangers were developed by officers of the navy on Coast Survey duty, and were promptly reported to the Office. "Notices to Mariners" were then issued giving full descriptions of the several localities, with distances and bearings of the rocks or shoals as referred to prominent objects. Statements in detail in regard to these dangers will be found in Part II with the names of the officers by whom they were reported:

No. 52 (August 11, 1884) gave information of a dangerous rock in East River, New York, near Dimond Reef.

No. 54 (October 7, 1884) described a rock off York Harbor, Maine; a rock between Marblehead Rock and Marblehead Neck, Massachusetts, and gave directions for avoiding Flip Rock, off Bass Point, Nahant.

No. 55 (November 1, 1884) warned navigators of a sunken ledge near Seal Rock, Rhode Island, and of two reefs developed in Long Island Sound; Six Mile Reef near the middle of the sound and about 6 miles from Clinton, Conn., and Northwest Reef in the vicinity of Brandford's Reef Beacon.

No. 56 (November 15, 1884) gave the results of an examination of an uncharted shoal between the western end of L'homme Dieu Shoal, Vineyard Sound, and Nobska light-house.

No. 57 (November 15, 1884) reported the discovery of a rock in Security Bay, Chatham Strait, Alaska.

No. 58 (February 10, 1885) announced the discovery of a number of shoal spots and rocky patches in the eastern part of Long Island Sound. Also the development of Sabine Bank off the coasts of Louisiana and Texas.

No. 59 (March 23, 1885) gave directions for avoiding numerous isolated shoal patches developed in Main Ship Channel, south of Great Round Shoal, Vineyard Sound.

Nos. 60 and 61 (March 23 and June 12, 1885) gave sailing directions for and cautioned navigators against dangers in Wrangell Strait, Alaska, and similar information in regard to the inland passage between Sitka Harbor and Hooniah Sound, through Olga Strait, Neva Strait, and Peril Straits, Alaska.

## IV.—SPECIAL SCIENTIFIC WORK.

## THE SECULAR VARIATION AND GEOGRAPHICAL DISTRIBUTION OF THE MAGNETIC DIP AND INTENSITY IN THE UNITED STATES.

In Appendix No. 6 is given an elaborate report by Assistant Charles A. Schott on the secular variation and geographical distribution of the magnetic dip and intensity in the United States. It presents a discussion of these elements, based upon a general collection of all observed values known to the author from the earliest times, and constitutes the last part of the magnetic researches respecting secular variation and distribution which for many years past have been in progress in the Survey. The secular variation and geographical distribution of the declination were discussed in papers which appeared as Appendices Nos. 12 and 13 to the Report for 1882. January, 1885, is the epoch of reduction adopted for each element.

An interesting result of the discussion of the secular variation of the dip is that Mr. Schott has been enabled to recognize and delineate a belt of "no change" for the epoch adopted, with annually increasing dip on one side and decreasing dip on the other. A similar feature was recognized in the discussion of the secular change of the horizontal intensity, the absolute measures for which date back hardly half a century.

These results, with the isoclinic and isodynamic curves, are graphically represented in the three maps and three diagrams which accompany the paper. One of these diagrams is a combination of the changes in declination and dip, showing the actual movement of a freely suspended magnetic needle for the period from 1820 to 1885.

## ADJUSTMENT AND REDUCTION OF THE DAVIDSON QUADRILATERALS.

In Appendix No. 9 are presented the results of the geodetic connection of the Yolo Base with the first side of the primary triangulation of California, forming part of what are known as the Davidson quadrilaterals. This paper, prepared by Assistant Schott, exhibits the results of the least square adjustment of a figure composed of seven stations and seventeen triangle sides, containing seventeen geometrical conditions. Sufficient detail is given to show the treatment by the Computing Division of observations of the first class, and the degree of accuracy reached in the results. It will be seen that these observations, whether compared with our own or with foreign measures, stand in the first order of precision, and they may well be taken as a piece of work representative of the accuracy attainable in modern triangulation. Respecting the analytical treatment, the subject of weights relative to the measured directions has received special attention, forming one of its distinguishing features, and the introduction of the process for the computation of the probable error of a resulting side will be found of interest.

## GEOGRAPHICAL POSITIONS AND HEIGHTS OF UPWARDS OF ONE THOUSAND STATIONS IN THE STATE OF MASSACHUSETTS, AND GEOGRAPHICAL POSITIONS OF ABOUT THREE HUNDRED STATIONS IN THE STATE OF RHODE ISLAND.

It is proposed to publish from time to time, as results become available, tables of geographical positions and heights in the several States in which the work of the survey is making progress. Appendix No. 8 contains the geographical positions and heights of upwards of one thousand stations in the State of Massachusetts and the geographical positions of about three hundred stations in the State of Rhode Island. Of the positions in Massachusetts, about one hundred were determined by the triangulation of that State executed by Simeon Borden between 1832 and 1838. A few points were established by the same triangulation in the State of Rhode Island. All of Mr. Borden's positions have been recomputed in this office in order to refer them to the standard data of the Survey.

## A PLEA FOR A LIGHT ON SAINT GEORGE'S BANK.

In Appendix No. 11, Assistant Henry Mitchell presents an urgent plea for the establishment of a light on Saint George's Bank. This great danger to seamen, lying upon the threshold of the Gulf of Maine, and 100 miles from the nearest land, is, as a shoal, far more dangerous than it would be as an island, and yet, as Mr. Mitchell observes, it is unmarked and undistinguishable except by its hideous roar when the ship is already within its breakers. As a warning and guiding mark to the ocean commerce of the Atlantic coast, and especially as a friendly signal to the fishing fleet of the Gulf of Maine, numbering at times four hundred vessels, carrying four thousand men, fishing on the Georges or crossing the shoals *en route* to more distant grounds, the benefits of such a light would be incalculable.

## COMPARISON OF TRANSVERSE SECTIONS OF THE DELAWARE RIVER BETWEEN OLD NAVY-YARD AND EAST END OF PETTY'S ISLAND, AS DERIVED FROM THE SURVEYS OF 1819, 1843, AND 1878.

The study of the changes in the channel-depths and cross-sections of Delaware River, undertaken of late years by Assistants Henry Mitchell and H. L. Marindin, is of immediate practical utility as bearing upon the effect of the construction of wharves and piers in contributing to such changes. Assistant Marindin presents in Appendix No. 12 a comparison of changes in transverse sections of that part of the river which embraces the principal part of the harbor of Philadelphia. His conclusions, as stated in the paper, and as graphically represented in the diagrams accompanying, are derived from the surveys of 1819, 1843, and 1878, and will have special value for the United States Advisory Commission on the improvement of the navigation of the Delaware.

## HARMONIC ANALYSIS OF THE TIDES AT GOVERNOR'S ISLAND, NEW YORK HARBOR.

In reports previously submitted and published as appendices to the annual reports of the Survey, the method of harmonic analysis has been applied by Prof. William Ferrel to the discussion of the tides of Penobscot Bay, of Sandy Hook, and of the Pacific coast (Appendices Nos. 11 of 1878, 9 of 1883, and 17 of 1882). The principles of this method were fully set forth, with rules, formulæ, and examples of the various reductions in the paper relating to the Penobscot Bay tides.

In Appendix No. 13 to this report is presented Professor Ferrel's paper on the harmonic analysis of the hourly co-ordinates of the heights of the tides at Governor's Island, New York Harbor, for the years 1876, 1877, and 1878. These hourly co-ordinates were measured from the curves recorded by the self-registering tide-gauge which had been maintained at that locality for many years.

Professor Ferrel remarks that there is a very great similarity between the tides at Governor's Island and those at Sandy Hook; that the amplitudes of all the separate tidal components are very nearly the same for both stations, but that, as was to be expected, the epochs at Governor's Island are somewhat greater, causing the tide to be about twenty-nine minutes later at that station than at Sandy Hook.



## EXPLANATION OF ESTIMATES.

The estimates submitted to the Department for the fiscal year 1886-1887 were accompanied by the following statement:

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,  
*Washington, October 12, 1885.*

SIR: I have the honor of submitting herewith the estimates of the appropriations required for the United States Coast and Geodetic Survey, for the fiscal year ending June 30, 1887, and respectfully request your approval thereof.

If it were definitely determined that the Coast and Geodetic Survey should continue to exist as a separate bureau, an immediate modification of its existing plan of organization, involving a corresponding modification in its efficiency and cost, would seem to be advisable. Such a modification should involve a reduction in the number and expense of the field, or so-called "normal force," and an increase in its efficiency by the elimination of the ineffective members, by so classifying the residue as to stimulate the junior element with a prospect of reasonably early promotion as the reward of skill and activity, and by abolishing entirely the system of payments and promotions upon the basis of longevity and putting them absolutely, as far as practicable, upon the basis of merit as indicated by the individual records of work performed.

In view, however, of the reference of matters relating to the organization of this and certain other bureaus of the Government to a joint commission appointed by Congress, and the consequent uncertainty involving the immediate future of this bureau, I have not felt warranted in attempting to anticipate Congressional action by submitting estimates predicated upon an experimental and temporary scheme of reorganization. The accompanying schedule of estimates is therefore made upon the basis of the existing plan of organization of the bureau as embodied in the Regulations for the government of the Coast and Geodetic Survey, issued from the Treasury Department February 18, 1881.

While the aggregate amount asked for, \$568,060, is somewhat larger than the amount appropriated for the current year, \$553,496.39, it is less by the sum of \$67,510 than the amount asked for the current year. The amount asked for the various classes of field-work is \$32,800 more than the amount appropriated for that class of work for the current year, while the amount asked for pay of field officers, office force, and office expenses is \$18,236.39 less than the amount appropriated for the current year for those items of expense. In other words, the estimates now submitted contemplate the performance of more work at a less cost for salaries and office expenses than was practicable under the appropriations for the current year.

The estimates for "Party Expenses," including work of furnishing points for State surveys, for Transcontinental Geodetic work, and for Resurveys of New York Harbor and San Francisco Bay, &c., cover the pay of those temporarily employed as recorders, signal-men, hands, cooks, drivers, or boatmen, or in any other capacity except as members of the permanent or normal force; the subsistence of the chiefs and employes of parties; traveling expenses to and from the field, and local transportation in the vicinity of field work; the transportation of instruments, tents, stationery, materials, outfit, and equipage to and from the field and in the field; and the purchase of all requisite materials, supplies, tents, boats, stationery, camp equipage, and all other necessary expenses properly incident to the prosecution of the work in the field.

An increase of the appropriation for "Party Expenses," as compared with the appropriations under that head for the current year, is, I believe, absolutely necessary to "a proper economic proportion between the expense of putting the various parties in the field and the length of time that they can be kept at work." After deducting from each appropriation for specific work the expense

of transporting the field party and equipage to and from the locality of that work, the balance of the appropriation measures the amount of effective field work capable of being done. To so stint the appropriation as to compel the withdrawal of parties from the field before the expiration of the season favorable to effective work, shortens the period of active work, lengthens the period of comparative idleness, increases the aggregate cost, and delays the final completion of the work, and is therefore a measure of false economy.

In conformity with the views of Congress as indicated in the appropriation for the current year, the estimates are itemized for the various purposes mentioned. Under that form of appropriation, the degree of caution necessary to avoid incurring deficiencies compels the withdrawal of parties from the field before the amounts appropriated for their respective schemes of work are expended. This results in the untimely interruption of much of the work, and in the creation of unexpended balances available for no purpose in the promotion of the business of the Bureau, unless a sufficient proportion of the appropriations can be made interchangeable to cover deficiencies resulting from the continuance of field work in some localities as long as favorable climatic conditions justify it. The ten per centum of interchangeability of the appropriations for the current fiscal year does not afford a sufficient margin to enable the Superintendent to adapt the expenditures and the field-work to the varying conditions of the various localities, and so to produce the best results from the amounts expended. It is therefore earnestly hoped that upon that point the suggestion of the estimates may be incorporated into the appropriation act and 20 per cent. of the amounts appropriated for "party expenses" be made available interchangeably for expenditure on the objects named.

In making estimates for salaries, the phrase "not exceeding" is employed with the purpose of determining their maximum, leaving without apparent limitation the authority of the Secretary of the Treasury or the Superintendent to reduce any of them in his discretion.

In apportioning the amounts asked for, the idea of prosecuting the survey of the coasts—the original purpose of this Bureau—to an early completion has been kept constantly in view.

In recognition of the practical value of geodesy to exact results in surveys of the public domain, as well as with a view to the maintenance of the honorable distinction achieved by this country in the scientific world, the estimate is somewhat increased beyond the amount appropriated for the current year for geodetic work, the scientific importance of which has enlisted in its prosecution abroad an association of the leading Governments of Europe.

It is hoped that the amount asked for resurvey of New York Harbor will be sufficient to complete the work, the progress of which during the current year has developed several dangers to navigation in those waters.

Included in the estimates is the sum of \$30,000 for the resurvey of San Francisco Bay and of the Straits of Karquines, and examination of San Francisco Bar and entrance, and of the mouths of the Sacramento and San Joaquin Rivers. The importance of these waters to the great commerce of the Pacific, and the marked changes constantly occurring in their character since the former surveys were concluded, which changes are largely due to the deposits of débris from hydraulic mining and from the heavy freshets to which the rivers mentioned are subject, render such resurvey highly desirable.

Very respectfully,

F. M. THORN,  
*Superintendent.*

The Hon. SECRETARY OF THE TREASURY,  
*Washington, D. C.*

#### ESTIMATES.

For every expenditure requisite for and incident to the survey of the Atlantic, Gulf, and Pacific coasts of the United States, including the survey of rivers to the head of tide-water or ship navigation; deep-sea soundings, temperature and current observations along the coasts and throughout the Gulf Stream and Japan Stream flowing off the said coasts; tidal observations; the necessary resurveys; the preparation of the Coast Pilot; a magnetic map of North America; and including

compensation, not otherwise appropriated for, of persons employed in the field work, in conformity with the regulations for the government of the Coast and Geodetic Survey adopted by the Secretary of the Treasury; for special examinations that may be required by the Light-House Board or other proper authority, and including allowance for subsistence to officers of the Navy attached to the Survey, not exceeding one dollar per day, as allowed by act of Congress approved June 12, 1858, and including traveling expenses of officers and men of the Navy on duty; the outfit, equipment, and care of vessels used in the Survey; and also the repairs and maintenance of the complement of vessels, to be expended under the following heads:

**FOR PARTY EXPENSES:**

For continuing the survey of the coast of Maine eastward from Machias Bay towards Quoddy Head.....	\$12,000
For examination of reported dangers and changes on the eastern coast.....	1,000
For continuing resurvey of Long Island Sound and finishing same.....	20,000
For completing resurvey of Delaware Bay, including current observations.....	2,000
For continuing examination of changes and resurveys on the sea-coast of New Jersey.....	2,000
For continuing examinations and surveys of estuaries of Chesapeake Bay, and of Sounds and tide-water passages in North and South Carolina not heretofore surveyed.....	4,000
For continuing the survey of the western coast of Florida from Estero Bay southward and from Saint Joseph's Bay northward, and hydrography of the same.....	10,000
For continuing the survey of the coast of Louisiana west of the Mississippi Delta, and hydrography on the coasts of Louisiana and Texas.....	5,000
To make off-shore soundings along the Atlantic coast and current and temperature observations in the Gulf Stream.....	9,000
For surveys and examinations of Monomoy Shoals, Nantucket Sound.....	2,000
For continuing the researches in physical hydrography relating to harbors and bars.....	2,000
For determinations of geographical positions (longitude party).....	5,000
To continue the primary triangulation from Atlanta towards Mobile.....	8,000
To continue the primary triangulation between Charleston, S. C., and the northwest corner of the State to connect with the oblique arc along the Blue Ridge.....	2,000
For continuing an exact line of levels from the Gulf to the transcontinental line of levels between the Atlantic and Pacific Oceans, and for continuing the transcontinental line of levels.....	4,000
To continue tide observations on the Atlantic coast.....	2,000
To continue magnetic observations on the Atlantic and Gulf coasts.....	1,000
To continue gravity experiments at a cost not exceeding \$500 per station, except for special investigations and experiments authorized by the Superintendent at one or more stations.....	3,500
To continue the compilation of the Coast Pilot, and to make special hydrographic examinations for the same.....	2,500
For continuing the topographical survey of the coast of Southern California.....	6,000
For continuing the primary triangulation of California.....	12,000
For continuing the survey of the coast of Oregon, including off-shore hydrography, and to complete the survey of the Columbia River and Willamette River to the head of ship navigation.....	12,000
For continuing the survey of the coast of Washington Territory.....	9,500
For continuing explorations in the waters of Alaska and making hydrographic surveys in the same.....	12,000
For traveling expenses of officers and men of the Navy on duty, and for any special surveys that may be required by the Light-House Board or other proper authority, and contingent expenses incident thereto.....	3,000
For continuing tide observations on the Pacific coast.....	2,500
For magnetic observations on the Pacific coast.....	2,000

## UNITED STATES COAST AND GEODETIC SURVEY.

11

For traveling expenses of the Superintendent and his party on duty of inspection...	\$600
For objects not hereinbefore named that may be deemed urgent .....	4, 000
And twenty per centum of the foregoing amounts shall be available interchangeably for expenditure on the objects named.	

In all, for party expenses .....	160, 600
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FOR FURNISHING POINTS FOR STATE SURVEYS .....	10, 000
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FOR TRANSCONTINENTAL GEODETIC WORK .....	36, 000
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For continuing resurvey of New York Bay and Harbor, including East River, to Throg's Neck .....	8, 000
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For resurvey of San Francisco Bay and of San Pablo and Suisun Bays and the Strait of Carquinez, and examination of San Francisco Bar and entrance, and the mouths of the Sacramento and San Joaquin Rivers .....	30, 000
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## FOR PAY OF FIELD OFFICERS:

For pay of Superintendent at not exceeding \$6,000 per annum .....	6, 000
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For pay of one Assistant in charge of Pacific coast operations, at not exceeding \$4,000 per annum .....	4, 000
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For pay of two Assistants at not exceeding \$3,500 per annum each .....	7, 000
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For pay of two Assistants at not exceeding \$2,800 per annum each .....	5, 600
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For pay of four Assistants at not exceeding \$2,500 per annum each .....	10, 000
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For pay of five Assistants at not exceeding \$2,300 per annum each .....	11, 500
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For p.y of six Assistants at not exceeding \$2,200 per annum each .....	13, 200
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For pay of seven Assistants at not exceeding \$2,000 per annum each .....	14, 000
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For pay of ten Assistants at not exceeding \$1,800 per annum each .....	18, 000
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For pay of nine Assistants at not exceeding \$1,500 per annum each .....	13, 500
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For pay of three Subassistants at not exceeding \$1,400 per annum each .....	4, 200
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For pay of two Subassistants at not exceeding \$1,300 per annum each .....	2, 600
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For pay of four Subassistants at not exceeding \$1,100 per annum each .....	4, 400
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For pay of eight Aids at not exceeding \$900 per annum each .....	7, 200
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For pay of one Aid at not exceeding \$720 per annum .....	720
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Total for pay of field officers .....	121, 920
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## FOR PAY OF OFFICE FORCE:

For one Disbursing Agent at not exceeding \$2,000 per annum .....	2, 000
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For four Clerks at not exceeding \$1,800 per annum (one to act as Librarian) .....	7, 200
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For one Clerk at not exceeding \$1,500 per annum .....	1, 500
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For eight Clerks at not exceeding \$1,000 per annum each .....	8, 000
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For nine Clerks at not exceeding \$800 per annum each .....	7, 200
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For two Computers at not exceeding \$1,850 per annum each .....	3, 700
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For one Computer at not exceeding \$1,800 per annum .....	1, 800
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For one Computer at not exceeding \$1,500 per annum .....	1, 500
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For one Computer at not exceeding \$1,400 per annum .....	1, 400
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For two Computers at not exceeding \$1,300 per annum each .....	2, 600
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For two Computers at not exceeding \$1,000 per annum each .....	2, 000
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For three Engravers at not exceeding \$2,000 per annum each .....	6, 000
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For two Engravers at not exceeding \$1,800 per annum each .....	3, 600
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For three Engravers at not exceeding \$1,500 per annum each .....	4, 500
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For one Engraver at not exceeding \$900 per annum .....	900
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For one Contract Engraver, contract not to exceed \$2,400 per annum .....	2, 400
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For one Contract Engraver, contract not to exceed \$2,100 per annum .....	2, 100
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For one Contract Engraver, contract not to exceed \$1,800 per annum .....	1, 800
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For one Contract Engraver, contract not to exceed \$800 per annum ....	800
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For four Draughtsmen at not exceeding \$2,000 per annum each .....	\$8,000
For two Draughtsmen at not exceeding \$1,800 per annum each .....	3,600
For one Draughtsman at not exceeding \$1,500 per annum .....	1,500
For three Draughtsmen at not exceeding \$1,400 per annum each .....	4,200
For two Draughtsmen at not exceeding \$1,300 per annum .....	2,600
For one Draughtsman at not exceeding \$1,200 per annum .....	1,200
For one Draughtsman at not exceeding \$1,100 per annum .....	1,100
For one Draughtsman at not exceeding \$900 per annum .....	900
For one Electrotypist and Photographer at not exceeding \$1,600 per annum .....	1,600
For one Assistant Electrotypist and Photographer at not exceeding \$1,150 per annum .....	1,150
For one Apprentice to Electrotypist at not exceeding \$360 per annum .....	360
For one Head Watchman and Janitor at not exceeding \$1,200 per annum .....	1,200
For two Watchmen at not exceeding \$800 per annum each .....	1,600
For one Messenger at not exceeding \$800 per annum .....	800
For three Messengers at not exceeding \$600 per annum .....	1,800
For three Messengers at not exceeding \$500 per annum .....	1,500
For one Driver at not exceeding \$600 per annum .....	600
For two Packers and folders at not exceeding \$600 per annum each .....	1,200
For four Laborers at not exceeding \$550 per annum each .....	2,200
For two Laborers at not exceeding \$360 per annum each .....	720
For one Fireman at not exceeding \$650 per annum .....	650
For one Fireman at not exceeding \$500 per annum .....	500
For one Map-mounter at not exceeding \$1,000 per annum .....	1,000
For one Map-mounter at not exceeding \$360 per annum .....	360
For one Carpenter at not exceeding \$1,500 per annum .....	1,500
For one Carpenter at not exceeding \$700 per annum .....	700
For one Carpenter at not exceeding \$500 per annum .....	500
For two Mechanics at not exceeding \$1,500 per annum each .....	3,000
For two Mechanics at not exceeding \$1,300 per annum each .....	2,600
For one Mechanician at not exceeding \$800 per annum .....	800
For one Mechanician at not exceeding \$500 per annum .....	500
For one Copper-plate Printer at not exceeding \$1,600 per annum .....	1,600
For three Copper-plate Printers at not exceeding \$1,200 per annum each .....	3,600
For two Copper-plate Printers at not exceeding \$700 per annum each .....	1,400
<b>Total for pay of office force .....</b>	<b>117,540</b>

**OFFICE EXPENSES:**

For the purchase of new instruments, for materials and supplies required in the instrument-shop, carpenter-shop, and drawing division, and for books, maps, and charts .....	12,000
For copper-plates, chart-paper, printers' ink; copper, zinc, and chemicals for electrotyping; engravers' and printers' supplies; for extra engraving; and for photolithographing charts for immediate use .....	11,500
For stationery for the office and field parties; transportation of instruments and supplies; office wagon and horses; fuel; gas; telegrams; ice; washing; and extra labor .....	8,000
For miscellaneous expenses, contingencies of all kinds, office furniture and repairs, and for traveling expenses of Assistants and others employed in the office sent on special duty in the service of the office .....	4,000
<b>Total for office expenses .....</b>	<b>35,500</b>

**FOR RENT OF OFFICE BUILDINGS:**

For rent of buildings for offices, work-rooms and work-shops, in Washington ... .. \$10,500

For rent of fire-proof building No. 205 New Jersey avenue, including rooms for standard weights and measures; for the safe-keeping and preservation of the original astronomical, magnetic, hydrographic, and other records, of the original topographical and hydrographic maps and charts, of instruments, engraved plates, and other valuable property of the Coast and Geodetic Survey ..... 6,000

Total for rent of office buildings... . 16,500

**FOR PUBLISHING OBSERVATIONS.**—For continuing the publication of observations and their discussion made in the progress of the Coast and Geodetic Survey, including compensation of civilians engaged in the work, the publication to be made at the Government Printing Office.. .... 6,000

**FOR REPAIRS AND MAINTENANCE OF VESSELS.**—For repairs and maintenance of the complement of vessels used in the Coast and Geodetic Survey, including the outfit, equipment, and care of the same ..... 26,000

Total amount estimated for United States Coast and Geodetic Survey for 1886-'87 \$568,060

Amount appropriated for the fiscal year ending June 30, 1886..... \$553,496.39

## PART II.

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This part of the report is occupied by statements in detail of operations afield and afloat, and by a summary of the work of the office. Its arrangement under the heads of sections is the same as that heretofore adopted. Appendix No. 1 presents in a geographical order the distribution of the field parties; in Appendix No. 4 is given the report of the Assistant in charge of the office.

The direction of office operations was continued during the year with Assistant Charles O. Boutele, whose assignment to that duty dates from January, 1884. Much of the time that he could spare from administrative work was devoted to the arrangement and preparation for publication of a new and enlarged edition of the projection tables, the computations for which were made under his personal supervision. These tables were published as Appendix No. 6 to the Report for 1884, and supersede all former projection tables published by the Survey.

Commander C. M. Chester, U. S. N., remained on duty as Hydrographic Inspector during the year. He had charge of the details of all hydrographic work, acting as chief adviser and executive officer of the Superintendent in matters pertaining to hydrography. As Inspector of Hydrography, and as in charge of the repairs and maintenance of the vessels of the Survey, his duties are in the field as well as in the office. The general charge of the Coast Pilot Division of the office is committed to him, as also the supervision of the labors of the office hydrographic draughtsmen.

In Appendix No. 5 is given in full Commander Chester's annual report, in which, in anticipation of his relief from the Coast and Geodetic Survey service, after having been connected with it for eight years, including five years duty as Hydrographic Inspector, he expresses his regret at severing personal relations of so pleasant a character and his sense of obligation for many courtesies received from his associates in the Survey. The Superintendent takes this occasion to express his high appreciation of the value of the services of this able and accomplished officer, and to say that it will not be easy to replace the professional skill and sound judgment, ripened by experience, which he has brought to the conduct of the work.

Administrative details in the Hydrographic Division were wholly in charge of Lieut. Jefferson F. Moser, U. S. N., Assistant Coast and Geodetic Survey, under whose direction Commander Chester reports that the best results possible are obtained. In December, 1884, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, who had been in immediate charge of the Coast Pilot Division, was relieved and transferred to the command of the steamer Blake. At the end of the fiscal year, Lieut. G. H. Peters, U. S. N., Assistant Coast and Geodetic Survey, was assigned in place of Lieutenant Pillsbury.

Mr. Edward H. Wyvill served acceptably as clerk in the Hydrographic Division; Messrs. E. Willenbacher, W. C. Willenbacher, and F. C. Donn as draughtsmen.

### SECTION I.

MAINE, NEW HAMPSHIRE, VERMONT, MASSACHUSETTS, AND RHODE ISLAND, IU DIN G COAST AND SEA-PORTS, BAYS AND RIVERS. (SKETCHES NOS. 1, 3, 17, AND 18.)

*Topography of Machias Bay entrance, Machiasport and the coast to the eastward.*—In continuation of the topographical survey of the coast of Maine in the vicinity of Machias Bay, Assistant Charles H. Boyd organized his party in June, 1884, and began the filling in of topographical

details upon the plane-table sheets of Machias Bay entrance and Machiasport. The bay and ocean shore-line upon these sheets had been laid down during a previous season.

Villages, farm lands, rocky hills, and extensive tracts of dense forests are the leading characteristics of the topography, which lies within the towns of Machiasport, East Machias, Whiting, and Cutler.

Mr. Boyd mentions, as matter of historical interest, that the ruins of an old trading post and block-house are still in existence a short distance north of Battery O'Brien, on Fort Point. They mark a site first occupied by Richard Vines, who in 1633 purchased of the Plymouth Council the exclusive right to trade with the natives of these coasts. In July, 1775, the Council of Safety ordered the mouth of the river to be fortified, and this fort, known as Fort O'Brien, was then garrisoned, and again in 1812. In 1862 an earthwork and magazine were built here, which are even now in a condition to be easily made serviceable.

At the "Rim," a long narrow point between the two branches of the Machias River, are the ruins of an old earthwork, known as Fort Foster. This was captured in August, 1777, by an English squadron under Sir George Collier.

Field operations were closed upon the completion of the sheets in October.

Mr. Henry R. Taylor, of Machias, served very acceptably during the season. The statistics of the work, which was on a scale of 1-10000, are as follows:

Miles of roads surveyed .....	47
Miles of creeks surveyed .....	7
Area of survey in square miles .....	20

Mr. Boyd is under instructions to resume the survey in this vicinity, and organized his party for that purpose in June, 1885.

During part of the winter he was on special duty in charge of the Coast and Geodetic Survey exhibit at the New Orleans Exposition.

*Topography of Chandler's Bay and Englishman's Bay, coast of Maine.*—Work upon the topographical sheet of Chandler's River and Bay, which had been begun by Assistant Eugene Ellicott in 1882, was resumed by him under instructions dated in July, 1884, and the sheet was finished about the end of August. The survey of the shore-line of Englishman's Bay, just west of Machias Bay, was then taken up and prosecuted to the close of the season.

Included in this sheet are the shore-lines of Rogue Island, Great Spruce Island, and Halifax Island, special care having been taken to determine the limits of low-water mark on these shore-lines.

Field operations were closed, and the party disbanded at the close of October. Mr. Ellicott refers in terms of marked approval to the services of Mr. J. H. Turner, aid in his party.

The statistics of the work, scale 1-10000, are as follows:

Miles of shore-line surveyed .....	51
Miles of road .....	20
Area surveyed in square miles .....	14

Duty subsequently assigned to Mr. Ellicott is referred to under the headings of Sections III and VI of this report. Towards the close of the fiscal year he was directed to take up and complete the topography of the shores of Englishman's Bay, and then to continue the survey to the eastward of Machias Bay.

*Hydrographic survey of Narraguagus River from Millbridge to Cherryfield; of Harrington River, including Flat and Back Bays, and of Pleasant River to Addison.*—In July, 1884, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, having, in pursuance of instructions, organized his party on board the schooner Eagle, began a series of hydrographic surveys to fill up gaps in previous work, and complete the hydrography in the vicinity of Narraguagus and Pleasant Bays. For this purpose he was furnished with three projections: one for the Narraguagus River from Millbridge to Cherryfield; one for Harrington River from its mouth to Harrington, taking in also Flat and Back Bays, and one for Pleasant Bay and River to Addison.

In Narraguagus River, zigzag lines were run about one hundred meters apart, the beginning



and ending of nearly all of the lines being determined by shore signals, and all lines run on ranges. This work completed the survey of Narraguagus River.

On the sheet of Harrington River, two sets of lines were run, one in the direction of and one normal to the course of the stream and about one hundred meters apart, except in Flat and Back Bays, where the system was opened to two hundred meters, and in the narrow part of the river, near Harrington, where zigzag lines were run. This survey was completed and connected with the work of 1883.

Lieutenant Heald observes that Flat and Back Bays and the narrow part of Harrington River are almost completely bare at low water. An excellent channel was found through what is known as Dyer's Island Narrows, or the Eastern Passage, which if properly buoyed could be navigated by coasting steamers at any stage of the tide. The buoys as placed at the time of the survey of Lieutenant Heald he found to mark a course that was not safe at low water.

Owing to the advance of the season it was not found practicable to finish the work on the sheet of Pleasant Bay and River, and the limit for closing was fixed at the line joining the river and bay. The survey of the bay was completed, and joins with previous surveys in this locality. Lines were run as on the sheet of Harrington River, one hundred meters apart, except in the deep part of the bay, where no evidence of shoal water could be found, when the system was opened to two hundred meters.

To determine a plane of reference for the soundings, tidal observations were made at the steamboat wharf, Millbridge, Narraguagus Bay.

In his report, Lieutenant Heald takes occasion to express for himself and for the officers who were associated with him the great satisfaction and pleasure they derived from the extremely accurate delineation of shore-line as given on their projections from the work of the topographical parties of the Survey.

Additional soundings and hydrographic examinations having been found necessary off Great Wass Island and Jordan's Delight Ledge, Lieutenant Heald was directed to make these on closing work in Pleasant Bay. This duty having been satisfactorily performed, he proceeded with the vessel and party to New York, where he arrived November 16.

Ensigns T. D. Griffin, A. Jeffries, and W. C. Canfield, U. S. N., were attached to the *Eagre* during the season.

The statistics of the hydrographic work, which was executed on a scale of 1-10000, are as follows:

Miles run in sounding .....	548
Angles measured.....	7,575
Number of soundings.....	44,518

Reference is made under the headings of Sections VI and VIII to duty subsequently assigned to Lieutenant Heald in southern waters.

*Topographical Survey in the vicinity of Prospect Harbor, Gouldsborough, Me., and resurvey of Bar Harbor, Mount Desert Island, Maine.*—The field-work of the topographical party in charge of Assistant A. W. Longfellow, during the summer and autumn of 1884, consisted in adding details of topography to complete the topographical sheet of Prospect Harbor, Gouldsborough, Me., and in a resurvey of Bar Harbor, Mount Desert Island, Maine.

Assistant E. F. Dickins was directed to report to Mr. Longfellow for duty, and joined his party July 22. From that date till the close of the season, November 10, Mr. Dickins was actively engaged in the field. He finished the plane-table survey of Prospect Harbor September 15, and then took up the resurvey of Bar Harbor. It had been at first intended to add the new streets, houses, &c., to the topographic sheet of 1873, but the growth of the town had been so extensive that this was found to be hardly practicable. The houses had increased since the former survey from one hundred and fifty to upwards of seven hundred, and the new villas built upon the hillsides afforded conspicuous landmarks to the navigator.

Upon the completion of field-work, Assistants Longfellow and Dickins repaired to Portland, where tracings were made of the plane table sheets. Mr. Dickins was detached from the party and ordered to duty at the Office towards the end of November. In his report of the season's op-

erations, Mr. Longfellow acknowledges the great value of Mr. Dickins's services in both field and office work.

*Record of observations with self-registering tide-gauge continued and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay.*—It is satisfactory to note that but a few years more of continuous record will be needed to complete a lunar cycle of one of the most perfect series of tidal observations obtained upon the Atlantic coast. No interruption has occurred in this series since it was begun by the present observer, Mr. J. G. Spaulding, in January, 1870. The locality, Pulpit Cove, sometimes called North Harbor, on the north side of North Haven Island, Penobscot Bay, was selected as one of the most favorable for the purpose in view, a thorough investigation of the laws of tidal action in the Gulf of Maine. Data derived from these observations were made the basis of Professor Ferrel's discussion of the tides in Penobscot Bay (Appendix 11, Report for 1878) and afforded valuable material to Assistant Mitchell for his paper on the Physical Hydrography of the Gulf of Maine (Appendix 10, Report for 1879).

*Hydrographic examinations off the coasts of Maine, New Hampshire, and Massachusetts.*—Certain dangers to navigation not laid down on the charts having been reported off the coasts of Maine, New Hampshire, and Massachusetts, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, was instructed at the beginning of the fiscal year to make search for and locate them.

His examinations off York Harbor, Maine, North Hampton, N. H., in the vicinity of Marblehead Rock, Massachusetts, and off Nahant, resulted in the publication of a Notice to Mariners in October, 1884, in which were given warnings of the following dangers:

I.—A rock reported off York, Me., on which the steamer City of Portsmouth struck, was found to have a depth of seven and one-half feet over it, and situated on the following bearings:

Cape Meddick Light-House, NE.  $\frac{1}{4}$  E., distant two and one-fourth miles.

Extremity of East Point, NW.  $\frac{1}{4}$  W., distant three hundred and thirty yards.

Boon Island Light-House, ESE.  $\frac{1}{4}$  E., distant six and one-fourth miles.

It is surrounded by other rocks, with depths from fourteen to eighteen feet, the outer one being marked by a buoy.

II.—A vessel was reported to have struck an unknown rock between Marblehead Rock and Marblehead Neck. In an examination of the vicinity a small boulder was found on the ledge, already known to exist, and shown on the charts of Salem Harbor. On this boulder there is seven and one-half feet, and it is situated about seventy-five yards from the nearest point of Marblehead Rock, with the Lowell (or Cat) Island Beacon just open of its northern point. Vessels keeping the middle of the passage will clear all dangers.

III.—Flip Rock, off Bass Point, Nahant, Massachusetts, reported by Mr. Edward W. Codman, was found to be a ledge about forty yards in length, having a least depth of thirteen and one-half feet at its shoalest point, and located on the following bearings:

Shag Rocks (Southeast Point) NE. by E.  $\frac{3}{4}$  E., distant one and one-eighth miles.

Bass Rock Spindle, N. by E.  $\frac{1}{4}$  E. five-eighths mile.

Boston Light-House, S.  $\frac{3}{8}$  E., four and three-fourths miles.

To clear this rock, if wishing to pass between it and Nahant, when abreast Shag Rocks, steer about SW. by W. for the large buildings on Deer Island. When Bass Point bears NW. one-half W., steer for it, being careful not to bring it to bear to the northward of NW. by N. until up with Bass Rock Spindle.

To pass to the southward of Flip Rock, do not bring Bass Point to bear to the westward of N. by W. one-half W. until the Shag Rocks bear ENE.

All bearings in the above Notice, as in all similar ones published by this Office, are magnetic, all distances in nautical miles, and all depths at mean low water.

Hydrographic duty performed by Lieutenant Pillsbury under subsequent assignment is referred to under the heading of Section VI.

*Continuation of the triangulation of the State of New Hampshire.*—The mountain station Pequawket, sometimes known as Kearsarge North, was occupied by Prof. E. T. Quimby, Acting Assistant, at the beginning of the fiscal year in continuation of geodetic operations in the State of New Hampshire. Pequawket is about four miles from the village of North Conway, in the White Mountain region. Professor Quimby decided, upon an examination of the road up the mountain,

that it was quite out of the question to attempt to establish his camp near the summit; hence the instruments and observing tent were sent to the top, while camp was pitched at the base, three miles from the station. The top of the mountain having been a favorite resort for tourists for thirty years, a hotel had been kept there, and the cupola of this house had been observed upon in the progress of the triangulation.

In November, 1883, a severe gale completely demolished the hotel and scattered its fragments far down the mountain. The removal of the house did not, however, prove to be of so much advantage as was at first anticipated, since the point on the ground corresponding to the center of the cupola was too low to afford an unobstructed view of the horizon. Almost immediately upon the arrival of the party the erection of another hotel had been begun, and this was pushed forward so rapidly as soon to obstruct three of the lines of sight from the point which was selected as a temporary station. A second position was therefore occupied which was adopted as the true station, and the observations taken from various points upon the old house cupola were reduced to the true station, with reference to which were determined the positions of the first or eccentric station, and of the chimney of the new house.

Upon the completion of the observations of Pequawket, in September, Professor Quimby went to Trask Hill, thirty miles to the southward, to measure a horizontal direction, and then visited several points in Rockingham County, among them Garrison Hill, in Dover. He found that it would be necessary to occupy an eccentric station here during the next season, the tower on the hill, upon which observations had been made from other points, not being suitable for occupation with the theodolite.

The following are the statistics of the season's work:

Number of horizontal directions determined.....	164
Number of vertical angles measured .....	14

*Stations occupied for continuing the triangulation of the State of Vermont.*—Two stations were occupied by Prof. V. G. Barbour during the summer and autumn of 1884 for the extension of the triangulation of the State of Vermont. On July 11 he established his party at station Gile, in the northern part of the town of Norwich, Windsor County. The necessary signals having been erected, one of them on Cube Mountain, in New Hampshire, and one on Ascutney Mountain, Vermont, and lines of sight opened, the horizontal direction of seven stations was determined by the 1st of August. Gile, being near the boundary line between New Hampshire and Vermont, was one of the stations observed upon by Professor Quimby from points in New Hampshire, and had been occupied by him previously to its occupation by Professor Barbour. It was found necessary therefore to observe upon but two of the New Hampshire stations, Cube and Corydon.

Station Cotton, in the town of Vershire, Orange County, was the next point occupied. Signals were erected on Moos-i-lauk and Bald Ledge, in New Hampshire, and on Potato Hill, in Vermont. The weather at this station being unfavorable, observations were somewhat delayed, but were finished September 12, the party being disbanded a few days later.

*Trigonometrical operations in aid of a topographical survey of the State of Massachusetts.*—The service rendered by Assistant Henry L. Whiting, under special assignment, as a member of the board of harbor and land commissioners of the State of Massachusetts, has been referred to in previous volumes of these reports. This special duty ceased at the close of the fiscal year with the expiration of Mr. Whiting's appointed term of three years' service on that board.

In June, 1884, plans were matured for a topographical survey and map of the State of Massachusetts, to be executed by the State in co-operation with the Geological Survey, and Mr. Whiting was appointed by the Governor one of three Commissioners to arrange the form and all details of the work on behalf of the State. His associates in this duty were President Francis A. Walker, of the Massachusetts Institute of Technology, and Prof. N. S. Shaler, of Harvard College. With the consent of the Secretary of the Treasury Mr. Whiting was authorized to accept this appointment, and was elected secretary of the Commission.

Application having been made by the Commission to this office to supply such additional triangulation in the State as might be needed for the proper execution of the topographical survey, Assistant Gershom Bradford reported under instructions to Mr. Whiting in September, and con-

tinued in the field in Southeastern Massachusetts until the 4th of December. During this time he reproduced ten of the points of a former triangulation by the Coast Survey, and five points of the Borden State survey made forty years ago, besides determining twelve new triangulation points, making twenty-seven points in all available for the topography.

Special appropriation was made by the State legislature, and approved March 27, 1885, for the cost of determining by triangulation the boundary line of the cities and towns in the Commonwealth under the direction of the Commissioners. Under application, duly made, two officers of the Coast and Geodetic Survey were detailed, with instructions to report to Mr. Whiting. Assistant F. W. Perkins was assigned to continue the determination of points for the State survey, and Subassistant C. H. Van Orden to the work of determining the boundary lines of cities and towns.

At the close of the fiscal year Mr. Perkins was occupied in furnishing triangulation points to the topographical party at work in the valley of the Connecticut River, while Mr. Van Orden took up a working ground with Boston as a center.

Mr. Whiting's duties under instructions in the Coast and Geodetic Survey, and as the executive member of the State Commission, have required his constant attention in the intervals of field work as well as during the season of its active prosecution.

*Hydrographic examinations off the coasts of Massachusetts and Rhode Island.*—In October, 1884, Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Blake, was directed to make certain hydrographic examinations in Vineyard Sound, Narragansett Bay, and Block Island Sound, with reference to the existence of dangers to navigation reported as not laid down on the charts.

The locality of his first examination was in Vineyard Sound, between the western end of L'Homme Dieu Shoal and Nobska light-house. Information had been received at this office from Captain Wright, of the schooner Kate Gifford, through the Hydrographic Office of the Navy Department, of the existence of an uncharted shoal in this vicinity. Lieutenant-Commander Brownson found two lumps to the westward of L'Homme Dieu Shoal, about five-eighths of a mile distant, and situated on the following bearings:

Nobska light-house, W.  $\frac{3}{4}$  N., two and three-fourths miles.

Holmes's Hole (West Chop) light-house, S. by W.  $\frac{1}{2}$  W. westerly, two and three-eighths miles.

East Chop light-house, S. by E., three and one-eighth miles.

The least water found over the lumps was twelve feet. There is deep water around them.

In the Notice to Mariners, which was promptly issued, the following directions were given:

To avoid this shoal in approaching from the eastward, continue on the course W.  $\frac{3}{4}$  N. from Succonesset Shoal light-vessel until West Chop light-house bears S. by W.  $\frac{1}{2}$  W., then change course to SW. by W.  $\frac{1}{4}$  W. for two miles, when Nobska light-house will bear NW. by W. The usual sailing line may then be followed.

In this Notice, as in all similar ones published by this Office, all bearings are magnetic and all distances in nautical miles. When depths are given they are at mean low water.

Examination of a shoal spot near Lucas Shoal, Vineyard Sound, led to the discovery of a small lump with thirteen and a half feet upon it at low water, and three hundred feet SW. by W.  $\frac{1}{4}$  W. (mag.) of Lucas Shoal. To have this lump well marked, the buoy was moved a short distance to the westward, as recommended by Lieutenant-Commander Brownson.

Early in November a rock reported near Gould Island, Sakonnet River, Rhode Island, was searched for. A ledge was found about ninety feet in length and thirty feet in width, lying in a W. by S. and E. by N. direction (mag.), with from two to nine feet on it at low water, and with deep water all around. This ledge bears W.  $\frac{3}{4}$  N. (mag.) from the north end of Gould Island, distant about six hundred feet. It lies on SW.  $\frac{5}{8}$  S. (mag.) bearing from the draw in the Stone Bridge. If it were buoyed on the eastern end, there would be plenty of room to pass between it and the island. The search for this ledge was conducted by Ensign William Truxtun.

On the 8th of November an examination made by Ensigns Edward Simpson and Miles Gorgas showed the existence of a rocky ledge two hundred and twenty-eight feet long and about nine feet wide S.  $35^{\circ} 45'$  W. (mag.) from the light-house on Dutch Island, Narragansett Bay. The outer end of the ledge is two hundred and eighty-five feet from high-water mark and four hundred and five feet from the light-house. For a distance of seventy-eight feet the inner end of this ledge is awash

at low water, then gradually deepening for one hundred and fifty feet to sixteen feet, and fifteen feet further off dropping down to four fathoms. The light-house keeper stated that during the past year eight schooners had struck on this ledge. During the flood-tide any vessel working in or out of Dutch Island Harbor is in danger of being set down on it. A buoy has since been placed to mark its outer edge.

Further examinations made by Lieutenant-Commander Brownson in Narragansett Bay and Block Island Sound led to the publication of a Notice to Mariners embodying the results, as follows:

(1) Shoaler water than that given on Coast and Geodetic Survey charts was found near Warwick, R. I., a patch with a least depth of seventeen feet being located S.  $\frac{1}{4}$  W. two and three-fourths miles from the light-house.

An examination of the waters off the upper end of Conanicut Island also showed a slight shoaling in patches of from one to three feet, the least found being eighteen feet, one-half a mile to the northward of North Point:

(2) In the vicinity of Point Judith several irregular rocky patches were found, having from three and one-half to four and three-fourths fathoms of water over them. These shoals extend around the point from NE. by E.  $\frac{1}{2}$  E. to SW.  $\frac{1}{4}$  W., with a radius of seven-eighths of a mile, except to the southward and eastward of the point, where the radius is one-half mile.

(3) A rocky patch with a least depth of sixteen feet was developed three-fourths of a mile W.  $\frac{1}{4}$  N. from Constellation Rock, entrance to Gardiner's Bay, on the following bearings:

Plum Island light-house, W.  $\frac{3}{4}$  N., three and three-fourths miles.

Little Gull Island light-house, NE.  $\frac{3}{4}$  N., two and one-eighth miles.

Gardiner's Island light-house, SW. by S., two and one-eighth miles.

Vessels of deep draught are cautioned against attempting to pass between Bedford Reef and Constellation Rock, as the intermediate bottom is irregular, with depths varying from seventeen feet to four fathoms.

Reference was made in my last annual report to surveys made by Lieutenant-Commander Brownson which developed changes in main Ship-Channel, Vineyard Sound, the existence of numerous isolated shoal patches with a least depth of seventeen feet having been shown to the south of Great Round Shoal.

The Light-House Board having rebuoyed the channel, a Notice to Mariners was published by this office, in which were given the following directions for entering:

Bring Sankaty Head light to bear SW.  $\frac{1}{4}$  S., and steer for it until Nantucket light bears W.  $\frac{1}{2}$  N. Head for this light on the course given until past the range of Shovel light-vessel on with Monomoy Point light, when head for Handkerchief light-vessel on a NW.  $\frac{1}{4}$  N. course. Continue on this latter course for about three miles, or until Nantucket light bears SW. by W.  $\frac{3}{4}$  W., when take a mid-channel course of WNW.  $\frac{3}{4}$  W. for Cross Rip light-vessel. The least depth of water on these sailing lines at date of survey was five and a half fathoms.

The following-named officers served in the party on the Blake during the season of 1884: Lieut. F. H. Crosby, U. S. N., Ensigns P. J. Werlich, William Truxtun, E. Simpson, jr., and M. C. Gorgas, U. S. N.

Upon closing work about the end of November, the Blake was taken to New York, and upon the detachment of Lieutenant-Commander Brownson from duty on the Survey, was placed under command of Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey.

*Magnetic observations at Providence, R. I., and on Coaster's Harbor Island, Narragansett Bay.*—In order to determine the changes that have taken place in the magnetic elements at Providence, R. I., since 1855, when a magnetic station was occupied in the grounds of the University, Sub-assistant J. B. Baylor was directed, in May, 1885, to observe for magnetic declination, dip, and intensity at, or as near as practicable to, the station of Assistant Schott. A new college building having been erected close to this station, a point was selected by Mr. Baylor in a large open space about 225 feet to the east of the former station, and near the college base-ball grounds.

A meridian for reference was obtained by observations on the sun, and the magnetic elements determined on three different days. For horizontal intensity observations were made with the magnetometer, and by the Lloyd method.

Similar observations were made at a new magnetic station located on the highest point of Coast-

er's Harbor Island, near Newport, the immediate object being to determine a magnetic variation for the new chart of Newport Harbor.

Mr. Baylor has transmitted his records and computations to the office. Duty assigned to him in the earlier part of the season is referred to under the heading of Section II.

*Hydrographic examinations in the approaches to Newport, R. I.*—Upon being detached in September, 1884, from the command of the schooner Drift, Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, was directed to transfer his party to the schooner Ready, and taking command of that vessel, to proceed with her to Newport, R. I., and make an examination of the rock or ledge in the approaches to that harbor, reported by Capt. J. N. Miller, U. S. N., commanding the steamer Tennessee.

After due search, Ensign Fechteler found the ledge, and it has since been buoyed. It is described in a Notice to Mariners, issued November 1, by this office, as a ledge about one-eighth of a mile in diameter, with a least depth of nineteen and one-half feet over it. The shoalest water was situated on the following bearings:

Seal Rock, N.  $\frac{3}{4}$  E., one-half mile.

Beaver-Tail light-house, NW. by W.  $\frac{3}{4}$  W., two and one-half miles.

Brenton's Reef light-vessel, W.  $\frac{1}{4}$  S., one and three-eighths miles.

Coggeshall's Ledge, ENE.  $\frac{1}{2}$  E., one and three-fourths miles.

In entering Narragansett Bay from the eastward, to avoid this ledge, keep Beaver-Tail light on a bearing to the northward of NW. by W. until Seal Rock bears NNE.  $\frac{1}{2}$  E.

Ensign Fechteler had the aid of Ensigns F. W. Kellogg and F. R. Brainard, U. S. N.

In connection with the resurvey of Long Island Sound, and off Cape Henry, Va., other examinations were made by Ensign Fechteler, which are referred to under the headings of Sections II and III.

*Tidal observations at Providence, R. I.*—Records for three successive years have recently been transmitted to this office by Samuel M. Gray, esq., city engineer of Providence, R. I., from the self-registering tide-gauge loaned to the city in 1872. Records for two more years have been promised. Some interruptions have occurred since 1882, but it is hoped hereafter to have these records continuous. Those already received have furnished good results.

## SECTION II.

CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING COAST, BAYS, AND RIVERS. (SKETCHES NOS. 1, 3, 4, 17, AND 18.)

*Topographical resurvey of the northeastern coast of Long Island in the vicinity of Gardiner's Bay, Shelter Island, and Greenport; also, of the north shore of the sound from Darien, Conn., westward.*—In continuation of the resurvey of Long Island Sound, Assistant Charles Hosmer was at work at the beginning of the fiscal year upon the topographical survey of the vicinity of Greenport and Southold, L. I. He had received his instructions towards the end of May, 1884, and had begun the filling in of topographical details west of Greenport early in June. The survey having been completed to include Great Hog Neck by the 20th of September, Mr. Hosmer transferred his party at that date to the schooner Drift to continue the shore-line survey of Gardiner's Bay and Shelter Island Sound.

Field operations were closed on the 5th of November, the advance of the season making it impracticable to continue the work to advantage.

Subassistant W. I. Vinal was attached to the party during the season, and rendered valuable assistance.

The statistics are:

Miles of shore-line surveyed .....	88
Miles of roads .....	61
Area surveyed in square miles .....	22

During the winter Mr. Hosmer was engaged in office work, and at the opening of the season in 1885 was instructed to organize his party for the continuation of the topographical survey of the

northern shore of Long Island Sound, between Darien, Conn., and New Rochelle, N. Y. He has furnished a sketch showing progress to the close of the fiscal year, and given statistics as follows to that date:

Miles of shore-line surveyed .....	39
Miles of roads .....	25
Area surveyed in square miles .....	5

*Continuation of the topographical resurvey of the north shore of Long Island to the west of Greenport.*—Instructions assigning to Subassistant W. I. Vinal the continuation of the shore-line topography of the south shore of Long Island Sound from the limits of Assistant Hosmer's work of the previous season were issued about the middle of May, and after some delay on account of illness, Mr. Vinal left for the field May 26.

He began the work just west of Goldsmith's Inlet, near the village of Peconic, on the 1st of June, confining himself to a narrow belt of shore-line topography, and to the erection of signals for the use of the hydrographic parties. The topographical features delineated were principally high banks of clay and gravel deeply eroded, detached bowlders inside and outside of the shore-line, many half-tide and low-water rocks, salt-marsh, scrub thickets, and patches of woodland.

Mr. Vinal's survey was making good progress at the close of the fiscal year. Up to that date the statistics are, scale 1-10000:

Miles of shore-line surveyed .....	13
Miles of roads .....	9
Miles of creeks and ponds .....	2
Area surveyed in square miles ..	3

Additional statements of progress will appear in the next annual report.

*Hydrographic examinations off Terry Point and Rocky and Horton's Points, Long Island.*—In order to fill certain gaps in hydrographic work off the north shore of Long Island, Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Ready, was directed, in September, 1884, to obtain the necessary soundings off Terry Point and Rocky and Horton's Points. Upon the completion of this work, he made a hydrographic survey of Southwest Ledge near Duck Island, to the west of Menunketesuck Point, finding no depth less than five fathoms.

Ensign Fechteler's examination of a ledge in the approaches to Newport Harbor has been referred to under the heading of Section I. Duty subsequently assigned to him off Cape Henry, Virginia, will be mentioned under Section III.

Ensigns F. W. Kellogg and F. R. Brainard, U. S. N., were attached to the Ready, and aided in the work.

*Topographical resurveys at the mouth of the Connecticut River, and near Milford and Stratford, on the north shore of Long Island Sound; also, from Lloyd's Neck eastward on the south shore.*—As stated in the last annual report, at the beginning of the fiscal year, Assistant W. C. Hodgkins was in the field in charge of a topographical party at Saybrook, Conn., in continuation of the resurvey of the north shore of Long Island Sound.

Work was continued in the vicinity of the villages of Lyme and Saybrook, at the mouth of the Connecticut River, until the end of August. It consisted mainly of interior topography and village details, in extension of the work of the previous season, where most of the shore-line had been surveyed. There was, however, some shore-line work in various coves and creeks which had not been reached before.

The character of the topography varied considerably. Over a great part of the area surveyed, the ground is low and rolling, and there are considerable areas of salt marsh which are cut up by numerous branching creeks. Between two or three miles back from the Sound, the ground rises rather suddenly to a range of rocky hills from one hundred to two hundred feet high. The villages of Lyme and Saybrook are situated on the low and nearly level ground south of these hills. They are quiet country places, each village consisting mainly of a single long street, very broad, and bordered on each side by lofty elms. Both villages were included in the area surveyed, to-

gether with the surrounding cultivated land, and enough of the hill border to show the character of the section.

On the 1st of September, the work near the mouth of the Connecticut having been completed, the party was transferred to Milford, Conn., to take up the resurvey of the shore-line between the work of Assistant R. M. Bache, west of New Haven, and that of Assistant E. Hergesheimer at Bridgeport. Between New Haven and Bridgeport the character of the country is much the same as that farther east. The hills, however, approach more closely to the shore, and more rock is found, forming numerous ledges offshore in the vicinity of Merwin's Point.

For the purposes of the plane-table survey, a small triangulation was laid out, four stations were occupied, and a number of spires and other prominent objects determined. At the time of closing field operations, November 15, some work had been done on the Housatonic River near Stratford and in Milford Harbor; some topography near the shore completed in details, and the entire extent of outer shore-line finished on two topographical sheets, to a junction with the topography near Bridgeport.

During the winter Mr. Hodgkins was engaged in inking his field sheets, and at the opening of the season in 1885 was instructed to resume field work. His party was organized May 18. In the vicinity of Stratford the survey of the shore-line was carried up the Housatonic River as far as the railroad bridge, and included the marsh formation opposite Stratford known as Nell's Island. The low-water outline was also surveyed, wherever it had been left incomplete last season, the high winds of the preceding autumn having made it impracticable to take a boat on the extensive shoals off the mouth of the Housatonic or among the rocks off Stratford Point.

At intervals, as the state of the tide favored, the survey was extended inland so as to include the whole of the island known as Stratford Point, and the creek or thoroughfare, locally known as the Gut, which separates the point from the mainland was surveyed throughout, to its junction with Bridgeport Harbor. This channel, which is nearly dry in many places at low water, forms a safe passage at high water for small craft between Bridgeport and Stratford.

Work in the vicinity of Bridgeport was closed June 11, and next day the party was transferred to Huntington, Long Island, to take up the resurvey of Lloyd's Neck and the shore to the eastward. At the close of the fiscal year, the necessary preliminary work of putting up signals and determining new points was well advanced.

Mr. J. W. G. Atkins was attached to the party as acting aid during the season, and rendered diligent service.

The statistics of work of the year in the several localities are as follows, the scale being 1-10000:

**Connecticut River:**

Miles of shore-line surveyed.....	30
Miles of railroads and other roads .....	24
Miles of creeks .....	22
Area surveyed in square miles.....	8

**Vicinity of Milford and Stratford, Conn.:**

Miles of shore-line surveyed.....	70
Miles of roads.....	22
Miles of creeks, including low-water and marsh outlines.....	50

**Huntington, Long Island:**

Miles of shore-line surveyed.....	5
Miles of roads.....	2

*Continuation of the topographical resurvey of the north shore of Long Island Sound in the vicinity of Madison, Guilford, and Branford, Conn.*—At the beginning of the fiscal year, the party of Assistant W. H. Dennis had been in the field for nearly a month, engaged in filling in the details of shore-line topography in the towns of Madison and Guilford on the north coast of Long Island Sound.

This survey connects with Mr. Dennis's work of the previous season in the town of Clinton. A small supplementary plane-table sheet had been laid out to cover Falkner's Island.

By the 17th of November, when field operations were closed for the season, the topography of



the Connecticut shore in the towns of Madison and Guilford, and that of Falkner's Island, was finished, and a beginning had been made on the plane-table sheet of the town of Branford, carrying the survey westward towards New Haven.

The statistics of work accomplished are as follows:

Miles of shore-line surveyed .....	39
Miles of roads surveyed .....	58
Miles of creeks surveyed .....	30
Area surveyed in square miles .....	17

Subassistant C. H. Oan Orden was assigned to duty in the party early in August, and served with great acceptance to the close of the season. Mr. J. W. Dudley rendered service as acting aid

In May, 1885, Mr. Dennis, who had been on office work during the winter, was instructed to re-organize his party for the continuation of the survey in the town of Branford. His report of the progress of this survey to the close of the fiscal year has been received. Many ledges and rocks were included in the work which could only be delineated at low water. The statistics to June 30 are:

Miles of shore-line surveyed .....	23
Miles of roads, creeks, and marsh lines .....	47
Area surveyed in square miles .....	6

Lieut. G. Lange, of the Norwegian general staff, was assigned to the party as aid on the 1st of June, and proved a very valuable assistant.

*Inshore hydrographic survey of the northern coast of Long Island Sound from Hammonasset Point to Welch's Point.*—In continuation of the hydrographic resurvey of Long Island Sound, Lieut. W. G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner *Palinurus*, was instructed, at the outset of the fiscal year, to organize his party on board of that vessel and take up the hydrography of the north shore of the Sound between Hammonasset Point and Welch's or Cedar Point, on the eastern side of Milford Harbor.

This survey was begun July 18, 1884, and was completed November 14. Its results are comprised in four hydrographic sheets on a scale of 1-10000, with limits as follows: Sheet No. 1, from Hammonasset Point to Sachem's Head; Sheet No. 2, from Sachem's Head to Branford Beacon; No. 3, from Branford Beacon to Southwest Ledge Light, and No. 4, from Southwest Ledge Light to Welch's Point.

The soundings upon sheets 1 and 2 were reduced to mean low water of a tide-gauge established on Falkner's Island; those on sheets 3 and 4 to mean low water of the Southwest Ledge Light-house tide-gauge.

Lieutenant Cutler has submitted a report of his season's work which bears witness to most careful and exhaustive study of the hydrographic characteristics of the localities included in his survey. Close examinations were made of all harbors or anchorages, sailing directions for entering given, and all dangers minutely described. His suggestions and notes will be of great value in future editions of the local Coast Pilot. Certain dangers developed by his survey, and not heretofore shown on the charts, were brought to public attention by the publication of the following Notice to Mariners, bearing date of November 1, 1884:

*Six-Mile Reef.*—This is an extensive patch of shoal ground lying near the middle of the Sound, about six miles from Clinton, Conn. The general depth of water covering the reef is from five to seven fathoms except on a small ledge situated near the western part of the reef. This ledge is about one-fourth of a mile in diameter and has three and one-fourth fathoms on its shoalest spot, which is located on the following bearings:

Falkner's Island Light-House, WNW., seven and one-eighth miles.

Southern extremity of Hammonasset Point, N. by W.  $\frac{3}{4}$  W., four and one-fourth miles.

Cornfield Point Light-Vessel, ENE.  $\frac{1}{2}$  E. five and one-half miles.

Horton's Point Light-House, S. by E.  $\frac{1}{4}$  E., six and one-half miles.

Vessels bound through the Sound from the Race, if following the directions for the main channel passing to the northward of Stratford Shoal Light, will pass about one-fourth of a mile to the southward of this rock.

*Northwest Reef.*—This is of very small extent, has a depth of six and one-half feet over it, with surrounding depths of five and six fathoms, and is located on the following bearings:

Branford's Reef Beacon, WSW., one and one-half miles.

Falkner's Island Light-House, ESE., five and three-fourths miles.

Lone Tree on Outer Thimble, ENE., seven-eighths of a mile.

All bearings in this Notice are magnetic, all distances in nautical miles, and all depths at mean low water.

Lientenant Cutler makes special mention of the fact that Branford Reef extends more to the northward than to the southward of the Beacon, and should not be approached from the northward nearer than about one-fifth of a mile. Branford Harbor he deems a very desirable anchorage for vessels drawing ten feet, desiring protection from the eastward, northward, or westward. It is not obstructed by ledges or sunken rocks and has no dangers which are not in sight or buoyed.

With regard to the approaches to New Haven Harbor, he observes that a breakwater two thousand one hundred and sixty feet in length now extends from Southwest Ledge Light in the direction of Quix's Ledge; hence the Light Lists and Buoy Lists, which state that Southwest Ledge Light may be approached close to on all sides, need some modification.

Ensigns F. H. Sherman and J. S. Watters, U. S. N., were attached to the *Palinurus*.

The statistics of the work are:

Miles run in sounding.....	515
Angles measured .....	6,677
Number of soundings.....	40,377

During the winter the *Palinurus* was laid up at the navy-yard, New York. As early as practicable after the appropriation for the resurvey of New York Harbor became available, Lientenant Cutler was assigned to duty on that work, reference to which will be made later in this report.

*Tidal observations with an automatic tide-gauge at the Light-House on the New Haven Breakwater.*—Mention was made in the last annual report of the completion of somewhat more than a year's record of the tides on a self-registering tide-gauge which had been established at Fort Trumbull, New London, Conn. At the beginning of the fiscal year this gauge was transferred to the Light-House on the New Haven Breakwater, and a tidal record was begun July 31, 1884, which was continued until December 2. This record was begun again May 12, 1885, and will be kept up during the season. It is under the general supervision of the chiefs of hydrographic parties in Long Island Sound, and will furnish a plane of final reference for the soundings as the hydrography reaches New Haven Harbor and advances westward.

*Continuation of the topographic resurvey of the north shore of Long Island Sound westward from Frost (or Farms) Point, and including the Norwalk Islands; also topographical resurvey of the shores of East River, New York.*—Towards the close of July, 1884, Assistant E. Hergesheimer, under instructions to resume the topographical resurvey of the north shore of Long Island Sound and carry it westward from the limits of his previous season's work, began field operations, and by the 16th of October had completed the topography of the north shore to South Norwalk and as far inland as the New York, New Haven, and Hartford Railroad. The survey included also the Norwalk Islands.

The statistics of this survey are:

Miles of shore line surveyed, including shore line of rivers, creeks, and ponds....	90
Miles of roads .....	44
Area surveyed in square miles .....	6

During the winter Mr. Hergesheimer inked his plane-table sheet with more than usual care as a sample of topographical delineation on a scale of 1-10000, and deposited it in the office.

For the purpose of noting topographical changes and additions on the water front of the inner harbor of New York and the East River, Mr. Hergesheimer left Washington under instructions on the 27th of October, and upon reaching New York made an examination of the water front of East River and the inner harbor, in order to decide in what localities the changes were so marked as to require resurveys, and the extent to which the local municipal surveys could be made available. After completing this examination, November 7, Mr. Hergesheimer returned to the office and submitted a detailed report of it with estimates of cost of surveys.

At the opening of the season in 1885 instructions were issued to Mr. Hergesheimer, acting under which he left Washington, April 27, and organized his party for a resurvey of the shore topography of the East River from Red Hook to Throg's Neck. In executing this work he was authorized to make use of such details of previous work by the Coast and Geodetic Survey, by the Department of Surveys of Brooklyn, and by the Department of Docks of New York City as upon verification in the field he might find to be trustworthy.

As the work progressed, tracings of shore line were supplied to the hydrographic parties. Mr. Hergesheimer had completed one table sheet and transmitted it to the office, and had begun a second soon after the close of the fiscal year. A fuller account of his work is necessarily reserved for the next annual report.

Mr. J. H. Gray was attached to the party as aid during both field seasons, and rendered acceptable service.

*Triangulation in the western part of Long Island Sound extended from Lloyd's Neck towards New Rochelle.*—At the beginning of the fiscal year, the party of Assistant Gershom Bradford was at Oyster Bay, Long Island, engaged in the preliminary work of reconnaissance and building signals for the extension of the triangulation of Long Island Sound westward from Captain's Island on the north shore of the Sound and Lloyd's Neck on the south shore. With some interruption, owing to delay in the passage of the appropriation, the work was continued until August 28, when it became desirable to assign Mr. Bradford to another field of duty. As already mentioned under the heading of Section I, he reported to Assistant Henry L. Whiting early in September to carry on under his general direction a triangulation in aid of the topographical survey of the State of Massachusetts.

After the close of field-work, December 4, in that State, Mr. Bradford was occupied during the winter in completing his records and computations, and towards the end of May, 1885, was directed to proceed to the western part of Long Island Sound, to furnish points for the topographical parties at work in that locality, and to continue his work of the season of 1884. Working eastward from New Rochelle, N. Y., on the north shore, he carried the triangulation to Captain's Island, and then crossed the Sound to Sea Cliff in Hempstead Harbor and closed the gap in the survey between the line Captain's Island–Oak Neck, the eastern limit, and the line Prospect Point–Whortleberry Island, the western limit, including Hempstead Bay.

Following are the statistics of field-work to the close of the fiscal year :

Number of stations determined .....	27
Number of horizontal angles observed .....	113
Number of measurements (direct and reverse) .....	1,404

At the date of which this report closes the triangulation is still in progress.

*Topographical resurvey of the north shore of Long Island Sound continued from Darien, Conn., towards New Rochelle, N. Y.*—Mention has already been made of the progress of the topographical resurvey of the north shore of Long Island Sound from Darien, Conn., westward under the first caption in this section. Assistant Hosmer, in charge of the party, has submitted a report with statistics, showing satisfactory progress up to the close of the fiscal year. A more detailed statement will be presented in the next annual report.

*Topographical resurvey of the shores of the East River, New York.*—At the date at which this report closes, a topographical resurvey of the shores of the East River, New York, is making excellent progress under the direction of Assistant E. Hergesheimer. Mention in some detail of this work has been made under a previous heading in this section referring to surveys westward from Farms (or Frost's) Point. In the next annual report a full account of it will appear.

*Hydrographic resurvey of the East River, New York.*—Early in May, 1885, Lieut. J. M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, was directed to organize a party on board of the schooner Eagle for the purpose of making a hydrographic resurvey of the East River, New York.

Having anchored the Eagle on the shoal to the southward of Governor's Island, and established a self-registering tide-gauge on the northwest corner of that island, near Castle William, Lieutenant Hawley by the 30th of June had completed the hydrography of the East River to Brooklyn Bridge, with that of a portion of the upper bay.

He had the aid of a steam launch from the Navy-Yard, and acknowledges the many courtesies extended to the party by the officers stationed at Governor's Island. He mentions also the great assistance rendered in the work by the shore line and positions of stations furnished by Assistant Edwin Hergesheimer, in charge of the topographical resurvey of the shores of the East River.

As may be supposed, much difficulty was experienced in that crowded port in running lines of soundings, on account of passing vessels. The launch carried a black ball on the flag-pole, and notices were published in the New York papers calling attention to the significance of this ball, but with the exception of the ferry-boats, few vessels gave the launch the right of way.

In addition to the regular lines of soundings, many lines were run, very close together, across Dimond Reef, upon which the least water found was twenty-one feet.

The statistics of the survey, upon a scale of 1-5000, to the close of the fiscal year, are as follows:

Miles run in sounding .....	156
Angles measured .....	2, 736
Number of soundings .....	11, 700

Ensigns F. H. Sherman, A. W. Dodd, and R. O. Bitler, U. S. N., were attached to the *Eagre*, and aided Lieutenant Hawley in the work. As it is still in progress, further mention of it is reserved for the next annual report.

*Determination of points for the resurvey of New York Lower Bay.*—Soon after the middle of April, 1885, instructions were issued to Assistant E. F. Dickens to proceed to New York and make the triangulation needed for the resurvey of New York Bay and Harbor. He was directed to concern himself first with the points required for the resurvey of the lower bay, and especially those on the south side of Coney Island and Rockaway Beach. He was to examine the condition of the old points with a view of recovering as many as practicable, re-establishing those that had been lost, and supplementing additional points where necessary.

In this work he was occupied till June 26, when he was detached and received orders to prepare for duty upon the Pacific coast.

Mr. Dickens reports the following statistics:

Stations recovered .....	8
Signals erected .....	12
Stations occupied .....	15
Objects observed .....	93

*Hydrographic resurvey of the entrance to New York Bay.*—In the spring of 1885, instructions were issued to Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, to fit the steamer *Endeavor* for service, and to proceed to make a hydrographic resurvey of New York lower bay and entrance.

The vessel arrived at New York from Norfolk April 28, and the party having been organized, preparations for the work by building signals, &c., were begun. Soundings were commenced June 2. A full report of operations is necessarily deferred to the next annual report. Up to June 30, the close of the fiscal year, the statistics were:

Miles run in sounding .....	320
Angles measured .....	5, 247
Number of soundings .....	16, 411

The following-named officers were attached to the party on board of the *Endeavor*: Ensigns C. S. Ripley, E. F. Leiper, F. R. Brainard, and G. R. French, U. S. N.

Other duty executed by Lieutenant Hanus is referred to under the headings of Section V and VI.

*Topographic resurvey of the shore lines of Coney Island and Rockaway Beach, New York Lower Bay.*—That portion of the topographic resurvey of New York Bay and Harbor which included the shore lines of Coney Island and Rockaway Beach was committed to the charge of Assistant Joseph Hergesheimer. He took the field June 18, 1885, and has submitted a report showing satisfactory progress during the limited time elapsing between that date and the close of the fiscal year. The next annual report will give a fuller account of this work.

Mr. Hergesheimer's field-work during the previous winter on the Gulf coast is reported under the heading of Section VI.

*Topographic resurvey of the shores of the North River, New York.*—Early in June, 1885, Assistant D. B. Wainwright was directed to proceed to New York and take up the topographical survey of the shores of North River, from Red Hook and Caven's Point to Fifty-ninth street and the opposite shore. The immediate object of this work was to supply positions and shore-line needed by the hydrographic parties. Mr. Wainwright was instructed also to confer with Assistant E. Hergesheimer in regard to obtaining and using data from the municipal authorities of New York and of the towns on the New Jersey shore, availing himself of all necessary shore-line within their control, but always determining the position of salient points by the plane-table.

In pursuance of these instructions, and to meet the wants of the hydrographic survey, he began by determining all prominent buildings and objects suitable for signals from the Battery to Fourteenth street on the New York side, and from Communipaw to Castle Stevens on the New Jersey side. Points on the upper topographic sheet were then determined on the New York shore and opposite from Fourteenth street to Eighty-third street. Tracings showing position of signals determined were furnished to the hydrographic parties.

Mr. Wainwright then began the work of delineating the shore-line on the New York side, and by the close of the fiscal year had completed the field survey from Fourteenth street to Sixty-fifth street. He found it advisable to extend the work somewhat beyond the assigned limits in order to include the new and very large docks of the New York Central Railway, which are also the last of any importance on the New York side.

Preparations were then made to take up the shore-line survey on the New York side from Castle Point to Weehawken Ferry. Further mention of Mr. Wainwright's progress is necessarily deferred to the next annual report. His services in the earlier part of the fiscal year are referred to under the heading of Section III.

*Hydrographic resurvey of the North River, New York.*—That portion of the hydrographic resurvey of New York Bay and Harbor included in the North River and its approaches, was assigned in May, 1885, to Lieut. William G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner *Palinurus*. Lieutenant Cutler began soundings May 23, and between that date and June 30 had finished the resurvey of the North River, with the exception of the wharf-lines from Castle Garden to Weehawken Ferry. The hydrographic projections furnished to Lieutenant Cutler for his work were upon a scale of 1-5000. A more detailed account of this survey will appear in the next annual report.

Ensigns E. E. Wright and A. G. Rogers, U. S. N., were attached to the *Palinurus*.

Mention has been made under a previous heading in this section of the hydrography executed by Lieutenant Cutler on the north shore of Long Island Sound, between Hammonasset Point and Welch's or Cedar Point.

*Development of plans for the study of the physical hydrography of New York Bay and Harbor.*—*Need of special examinations to ascertain the physical history of the changes in Monomoy Shoals.*—As soon as practicable after the appropriation for the resurvey of New York Bay and Harbor became available, Assistant Henry Mitchell was directed to reopen the study of the physics of the harbor, and supervise the further collection of data for the purpose of ascertaining the laws of action of its tides and currents.

Assistant H. L. Marindin was at the same time instructed to organize a field party with such subdivisions as Mr. Mitchell might advise, and authority was given to procure by transfer from the service of the Mississippi River Commission two trained experts in river gauging. To Mr. Marindin's party Assistant Marcus Baker was assigned, his instructions, dated May 28, 1885, directing him to proceed to Boston and report to Mr. Mitchell for general conference and consultation in conjunction with Mr. Marindin.

At the date at which this report closes, two parties had been organized for the hydrological survey, one in the schooner *Drift*, under the command of Lieut. F. S. Carter, U. S. N., Assistant Coast and Geodetic Survey, and the other in the schooner *Scoresby*, Assistant Marcus Baker commanding. Their work was to ascertain what are the functions of the different bays and rivers emptying into New York Harbor in maintaining the depths over Sandy Hook Bar.

Mr. Mitchell has indicated the following physical questions as among the most important, per-

haps, that have remained unsolved with regard to the projects of encroachment in different parts of the harbor:

- (1) In what relative proportions do the two entrances of the harbor supply its tidal volume?
- (2) In what relative proportions do the two entrances to the harbor discharge the river waters, and how do these proportions differ with floods and low stages of the Hudson?
- (3) To what depth, if limited, does the influence of the river water extend, and how does this depth vary with amount of river discharge?
- (4) To what extent is the Hudson River a tidal reservoir as affecting New York Harbor; i. e., at what distance above New York would an exclusion of the tide reduce the flow through the harbor below, at the period of least fresh-water discharge?
- (5) What is the physical value of Newark Bay as a tidal reservoir tributary to New York Harbor?

With regard to this important harbor, Mr. Mitchell remarks that the former physical survey cannot be repeated to advantage except by an expenditure of time and money that will make it practicable to occupy a number of points simultaneously, so that the work will faithfully reflect all that goes on in the great channels at the same instant of time.

*Monomoy Shoals.*—Very serious apprehensions are felt relative to the increase of obstructions at the eastern entrance to Nantucket Sound, and great difficulty has been experienced in keeping the chart correct, especially as regards the sailing lines. The increase of the shoals and their movements have been pretty well connected with the rapid degradation of the shores of Cape Cod, at and above Chatham, so that it is almost certain that some movements of the sea, not yet properly gauged, must account for both the destructive and constructive phenomena observed.

Although glacial cliffs along the coast are everywhere giving way before the dash of the sea, the destruction is not rapid, except where there runs in some ocean current (tidal or otherwise) to carry off the débris as fast as it falls into the sea. One observes from a comparison of ancient and modern charts, and even from repeated surveys in our own time, that the submerged contours near the elbow of Cape Cod fall back somewhat as the coast recedes, and the Monomoy Shoals increase as they move to the southwestward.

This movement of the shoals has reduced the width of the channel known as "Butler's Hole" to one-half its former width, and has shown across the great south channel "lumps" of deposit, which render the deep track tortuous and dangerous.

In his annual report, Mr. Mitchell recommends that the physical history of these changes be ascertained, not only by comparing ancient and modern maps and surveys, but by observing the waves and currents till the dynamic scheme is plainly brought out. It may be that no remedy for the deterioration is possible, but until a diagnosis of the case has been made, no such verdict can be declared against the interest of over twenty-five thousand vessels that annually pass this way.

*Mississippi River Commission.*—The survey is represented by Mr. Mitchell upon the Mississippi River Commission. Much of his time is thus employed, but not to the exclusion of other duties. His relation to the work of the Commission he makes a theme in his annual report for the sake of recording his objection to the proposed high-water closure of the Atchafalaya, on the ground, principally, of its increasing the velocity of the great floods to an extent that would sometimes prevent vessels from towing up to New Orleans from the sea, should the present river banks (and lands adjacent of almost incalculable value) hold against the wear of the main stream.

*Advisory Commissions.*—In his annual report, Mr. Mitchell, referring to advisory commissions in general, says: "They are a body of experts who study the physical data and the generic wants of navigation. In recommending the harbor lines, those beyond which no one shall build and to which building in a certain order shall be prosecuted, the advisory board does not recognize individual interests or enterprises, although it frequently happens that the adjustment of rival interests turns upon its decisions. It is usually the function of the local commission to have hearings of parties in interest, and settle disputes, but an appeal is made to the advisory commission in all cases where decisions may rest upon physical data. The particular value of the advisory commission appears when two rival interests, both disposed to be fair, but each jealous of the other, find themselves confronted by a physical reason, a reason based upon the natural laws of the tides, currents, or cross-sections. I have so often seen cases settled in this way that I have

come to think a physical reason the best reason, because recognized as *higher law*. One may easily see that rival claimants for water space on opposite shores of a river cannot be equally entitled, because the river flow is not the same on the two shores, and encroachment from one shore must disturb it more than from the other. In very many ways such inequalities present themselves, and the party losing discovers that his best interests lie in gracefully and promptly yielding to a reason which the community is ready to adopt."

Special reports have been presented by Mr. Mitchell respecting the necessity of a light-house upon George's Shoal, and upon the changes in extent and location of the shoals in Delaware Bay.

Later, under the heading of this section, is given a résumé of the work of Assistants Mitchell and Marindin with reference to the adjustment and solution of important practical questions affecting the navigation of Delaware Bay and River, and the respective limits of jurisdiction of the States of New Jersey and Delaware over the waters of the river and bay.

*Records of observations with self-registering tide-gauges at Governor's Island and at Sandy Hook.*—Early in May, 1885, an automatic tide-gauge was established on the wharf at Governor's Island, New York Harbor, to be used in connection with the hydrographic resurvey of the harbor and bay. This gauge will have the supervision of the naval officers in charge of the hydrographic parties in that vicinity. The records from the self-registering gauge which was maintained at the same location on Governor's Island for upwards of sixteen years, ending in 1879, yielded valuable data for the study of the tides of New York entrance.

The automatic tide-gauge at Sandy Hook, New Jersey, which has been kept in operation with comparatively few interruptions for several years, was in charge of Mr. F. W. Shephard during July and August, 1884. A stoppage of several months then followed, owing partly to the necessity of repairing the gauge, and of training a new observer, Mr. Shephard having resigned. Towards the end of March Mr. J. W. Corbett was placed in charge, and records have been received since the close of that month.

*Topographical resurvey of Sandy Hook, New Jersey.*—Changes in the shore-line of Sandy Hook and of the hydrography in its vicinity, as affecting the main ship channel abreast of the Hook, have called for much study, based upon careful resurveys, to ascertain the laws governing these changes, and to determine their extent and influence. In connection with the resurvey of New York Bay and Harbor, a topographical resurvey of the Hook was deemed essential, and early in June, 1885, this work was assigned to Mr. E. L. Taney, an aid in the Survey of tried ability as a topographer. Mr. Taney organized his party and arrived at the Hook June 16, and at the date at which this report closes was actively at work. Further mention of his progress will be made in the next annual report.

*Extension of reconnaissance and triangulation in the southern part of the State of New Jersey.*—As stated in my last annual report, geodetic operations in the southern part of the State of New Jersey were resumed by Prof. E. A. Bowser, acting assistant, at as early a date as practicable in the spring of 1884. At the beginning of the fiscal year Professor Bowser had selected a sufficient number of points to the west and southwest of Williamstown, Gloucester County, to close the horizon around that station. The country being mostly flat, and in many places heavily wooded, signals ranging in height from forty to upwards of one hundred feet had to be erected to make the reconnaissance successful.

On July 7 the occupation of stations of the triangulation was begun, additional reconnaissance having been postponed till later in the season. Station Applepie Hill, about five miles west of the town of Shamong, Burlington County, was first occupied. Five primary points were observed upon from this station, the point farthest to the east being Ridgeway, distant from the Atlantic coast a little over seven miles, and the most western point, Berlin, being within twelve miles of the Delaware River.

Upon the completion of observations at Applepie Hill, August 26, the old monument which had marked the station was placed five and a half feet below the surface of the ground, and a granite post of the usual dimensions for a surface mark was set in hydraulic cement, its top, upon which the center of the station had been marked, being within six inches of the surface.

Berlin Station, near the town of that name, in Camden County, was next occupied, and on the

26th of September, all observations at this station having been finished, the point was marked in the same way as the first station.

The triangulation closed November 5 with the occupation of station Mount Holly, Burlington County, and on the next day Professor Bowser resumed the reconnaissance, and by the end of the season had carried it southward to the line Kellogg-Russia, the latter station being about seven miles northwest of Tuckahoe, on the river of the same name, which flows into Great Egg Harbor, and the former three and a half miles northeast of Millville, Cumberland County.

Following are the statistics of the work:

Number of angles measured between primary stations.....	18
Number of angles measured between secondary and tertiary stations.....	20

At the opening of the season in 1885 Professor Bowser was instructed to take the field in continuation of the reconnaissance and triangulation of the State.

*Extension of reconnaissance and triangulation in the eastern portion of the State of Pennsylvania.*—Up to the beginning of 1884, the geodetic operations carried on for some years preceding in the eastern and southeastern portions of the State of Pennsylvania had determined accurately in geographical position thirteen stations of the triangulation resting on the fixed primary lines Meeting House-Principio and Newtown-Mount Rose.

A large number of subsidiary points had also been determined, including church spires and prominent buildings. Through the line Newtown-Mount Rose a connection had been obtained with the triangulation of the State of New Jersey.

Early in July, 1884, Prof. Mansfield Merriman, acting assistant, was instructed to organize a party for continuing the triangulation and reconnaissance, and began the occupation of station Swatara Gap, about eleven miles northwest of Lebanon, Lebanon County.

Heliotroppers were posted at Womelsdorf, Round Top, and Dauphin; a tower with signal was erected at White Horse, and a signal placed at Governor Dick. But few observations could be taken in July, the weather being foggy and rainy. The line from Swatara Gap to Round Top, upwards of thirty-two miles long, led across the valley of the Susquehanna, and over the Steelton Iron Works, and no measurements of its direction could be obtained until August, and then at but rare intervals. On account of these difficulties, the observations at Swatara Gap could not be completed till August 30, when the triangulation was closed, and the limited time remaining devoted to reconnaissance.

Professor Merriman's first efforts were directed toward a revision of the location of stations west and southwest of the meridian of  $77^{\circ}$ , so as to obtain a favorable connection with the Maryland triangulation through the stations Fairview and Maryland Heights. This was accomplished by selecting a very prominent point, Mount Misery, in Maryland, about a mile south of the State line, and 2,300 feet elevation above tide. In Pennsylvania this station connects with Piney Mount and Pulpit Rock.

During part of August and in October, Professor Merriman began a reconnaissance along the meridian of  $76^{\circ}$  in the vicinity of Mauch Chunk, Carbon County, for the purpose of connecting the triangulation of Pennsylvania with that of New York. The reconnaissance was carried to within seven miles of Wilkes Barre, Luzerne County. Field-work was closed in October.

In order to expedite this reconnaissance and allow more time to Professor Merriman for the triangulation during the two or three months of each year available for his field operations, Assistant O. H. Tittmann was directed in June, 1885, to continue it northward from points already established, so as to include in the trigonometric network the coal fields of Luzerne County. He was instructed also to determine whether it was practicable, in the locality just mentioned, to develop the reconnaissance for the primary scheme incidentally to the work of fixing trigonometric points with sufficient accuracy for the collocation of local topographical State surveys on a general map.

Professor Merriman was at the same time directed to resume work upon the triangulation of Pennsylvania as early as practicable, and his co-operation with Assistant Tittmann was provided for.

A statement of the results reached by the labors of these gentlemen is necessarily deferred to the next annual report.



*Reconnaissance for triangulation in the western half of the State of Pennsylvania.*—Towards the close of the fiscal year, the appointment of Prof. L. H. Barnard as acting assistant was renewed and he was charged with the conduct and execution of the work of triangulation in the western half of the State of Pennsylvania. He was directed to begin by making a reconnaissance of precision connecting two points on the Tussay Mountain, or on Broad Top, with points already determined in the vicinity of Lancaster and Harrisburg.

Professor Barnard visited Washington, and after having informed himself thoroughly of the conditions and limitations of the work in conference with the Superintendent, conferred also with Dr. Charles A. Ashburner, geologist in charge of the anthracite coal fields of the State, in reference to the operations desired by the State Geological Survey. An account of his progress will find a place in the next annual report.

*Special triangulation for the city of Philadelphia.*—A request having been made by Mr. Samuel L. Smedley, Chief Engineer and Surveyor, in behalf of the authorities of the city of Philadelphia, for the trigonometric determination of a number of points in and around the city, Assistant S. C. McCorkle was directed to execute this work after conference with Mr. Smedley, and began the preliminary reconnaissance towards the end of November. Other duties interfered to prevent the completion of the reconnaissance by Mr. McCorkle, and early in January, 1885, Subassistant C. H. Van Orden was directed to report to him. By the end of that month Mr. Van Orden had finished the reconnaissance, erected five signals, and occupied four stations. Exposure to wind and cold at a station on the roof of Girard College January 31 brought on an attack of illness, which for a time completely prostrated Mr. Van Orden and compelled his relief from field duty. Some delay was thus occasioned, but towards the end of February Assistant C. H. Sinclair was ordered to take up the work under Mr. McCorkle's direction, and by the end of March he finished it.

During its progress the tower of the new City Hall, which had then reached an elevation of one hundred and ninety-two feet, was occupied as a station.

The statistics of the work are:

Number of points determined.....	19
Number of angles measured . . . . .	151
Number of observations . . . . .	1,680

It remained to connect this local triangulation with the primary series, and for this duty Mr. Van Orden, whose health had been restored, was directed in April, 1885, to report to Mr. McCorkle. The line Mount Holly-Girard College was at first proposed as the desired base, but finding it practicable only by expensive opening of lines, the line Pine Hill-Girard College was substituted. This line, in connection with the station at Bellevue Hotel, Red Bank, N. J., presented a satisfactory solution of the problem. The stations at Girard College and Bellevue Hotel were reoccupied for the measurement of additional angles in order to give greater weight to observations previously made. In all fourteen angles were measured and five points determined in positions by three hundred and twenty-four observations. The results of this work and of that before referred to have been communicated to the city Chief Engineer.

In the annual report for 1879 mention was made of an examination of the movement of ice in the Delaware, conducted by Mr. McCorkle along the stretch of river from Bridesburg, above the city, to Fort Mifflin, below it. Similar examinations were made, in pursuance of instructions, by Mr. McCorkle during the winter of 1884-1885, which is said to have been one of the most severe known there for forty years. The ice was found to be unusually heavy, notably below the Horseshoe. The largest accumulations of ice were found at the Narrows, between Gloucester and Greenwich Points, in the bend at the Horseshoe, and below Fort Mifflin.

Mr. McCorkle has submitted a full report of the results of his observations, accompanied by illustrative maps, and the recommendations he makes will be of interest to the United States advisory commission on the improvement of the Delaware River.

*Physical hydrography of Delaware River and Bay.*—The studies of the physical hydrography of Delaware River and Bay, especially those bearing upon the changes in the extent and location of the shoals, have been continued by Assistants Henry Mitchell and H. L. Marindin.

Mr. Mitchell has submitted a report which reflects fairly the aspect of his work, and in which

he refers to an important practical conclusion, drawn from his study of the river and bay, and which settled a question of jurisdiction between the States of New Jersey and Delaware, and between these two States and the General Government.

Some extracts from this report are as follows :

"Quite beyond the jurisdiction of the Harbor Commission of Philadelphia or its advisers, we have been making a study of the changes in the extent and location of the shoals. My own part has been inquiries into the general laws of sectional areas, in which I have been assisted, fortunately, by Mr. J. A. Sullivan, upon whom most of the work has fallen. Appendix 8, Report for 1883, established certain laws of depth and surface width, and gave rise to the question: Is the surface width a proper criterion; should it not be the mean chord, or perhaps the chord of mean depth? A computation of mean chord was clearly out of the question, but Mr. Sullivan undertook the computation of the chord of mean depth, and I insert his table, with illustrative diagrams, on which we are not yet prepared to offer conclusions. I want, however, to record one thought about the mean section that may prevent its misleading; it is this: Since for these forty-six miles right hand and left hand turns enter the mean section, it cannot be a characteristic natural section, but must be nodal.

"In the appendix to the report for 1883, referred to above, I took some pains to call attention to very important practical conclusions from a study which might otherwise have appeared speculative. At that time I did not dream that this study would come to have political value, but it appears from the report of Hon. John P. Stockton, Attorney-General for New Jersey, and from the letter of Hon. John H. Paynter, Attorney-General of Delaware, that a question of jurisdiction between these two States, and between these States and the General Government, is likely to be settled to the satisfaction of all parties upon the basis of our solution of a physical problem. And here I must repeat what I said in a former report when commending advisory harbor commissions, that a physical reason is the best reason because the higher law."

A brief statement of the question of jurisdiction referred to by Mr. Mitchell will be in place here. Citizens of the State of New Jersey had claimed and exercised the right of fishing in the river Delaware. This claim had been resisted by the State of Delaware, and the boats and nets of the New Jersey fishermen had been seized by Delaware on the charge of violating the statute laws of that State by fishing within its limits. This had been done notwithstanding the fact that an injunction of the Supreme Court of the United States had been issued forbidding such action by the State of Delaware, the authorities of that State claiming that their statute laws had been violated because the fishing was done within the limits of Delaware in Delaware Bay, and not within the area covered by the injunction of the Supreme Court, which applied only to the river.

It became important, therefore, to define the territorial limits over which the injunction operated, or, in other words, to ascertain the dividing line between the river and bay. The Governors of the two States interested having referred this question to their respective Attorneys-General for settlement, it was agreed by these officers to accept the decision of the Superintendent of the Coast and Geodetic Survey. The conclusion reached by the Superintendent, and confirmed by Assistant Mitchell, was that the dividing line was properly one from Bombay Hook Point to Cohansey light, a conclusion which, in view of the large interests involved in the controversy, attests the practical value of studies not unfrequently classed as purely speculative.

Assistant Mitchell refers to a report prepared by Assistant Marindin on a comparison of the changes in the transverse sections of the Delaware River between Old Navy-Yard and the east end of Petty's Island, as shown by the surveys of 1819, 1843, and 1878. This report, with illustrative diagrams, appears in Appendix No. 12.

Reference was made in the last annual report to Mr. Marindin's assignment to duty as Consulting Engineer of the United States Advisory Commission for port-warden lines for the harbor of Philadelphia. Until about the middle of October Mr. Marindin was occupied on the comparisons of surveys; he then received a call from the chairman of the Advisory Commission, and after preparing the port-warden lines for discussion, he attended a meeting of the Commission in December. In the early part of January he was directed to collect some data with a view of showing the importance of marking George's Shoals; on this subject he made a special report to Mr. Mitchell, who was then engaged on that inquiry. Subsequently he was ordered to proceed to Washington

for conference with the Superintendent, and then to Philadelphia to take charge of a hydrographic and topographic survey of the Delaware River above Bridesburg. He was, however, soon relieved from this duty and directed to prepare for work in connection with the resurvey of New York Bay and Harbor. Mention of this has already been made under a preceding heading in this report.

Upon the Commission advisory to the Harbor Commission of Philadelphia, the Survey is represented also by Mr. Mitchell, to whom was tendered recently the chairmanship. But he deemed it best to decline the position, as it seemed to him that either of his two associates might more properly preside, both being in charge of public works in the neighborhood. Capt. George B. White, U. S. N., was accordingly elected. The third member is Col. Henry M. Robert, United States Engineers. Towards the latter part of June, 1885, Mr. Marindin was informed that he had been elected secretary of the board.

*Special triangulation. Delaware River from Petty's Island to Poquessink Creek.*—An extension of the survey of the Delaware River from Petty's Island to Poquessink Creek, the northeastern boundary of the city, having been requested by the city authorities, Assistant F. W. Perkins was directed to proceed to Philadelphia and execute the work, after conference with Mr. Samuel H. Smedley, Chief Engineer of the city.

Mr. Perkins began a reconnaissance of the ground to be covered early in November, and by the 20th of that month was able to begin observations. Progress being slow, owing to bad atmospheric conditions, Subassistant Van Orden was ordered to report to Mr. Perkins soon after the beginning of December, and with his energetic aid field work was finished by the end of the year. The triangulation determined all the points needed for a topographical and hydrographical survey of the most detailed nature.

Following are the statistics :

Number of points occupied .....	13
Number of positions determined ... ..	53
Number of observations made.....	3,318

Assistant Perkins expresses his obligations to Chief Engineer Smedley for many courtesies and liberal facilities in the execution of the work, and to Mr. George S. Webster, surveyor of the tenth district, for much valuable assistance and information.

Other duty assigned to Mr. Perkins is mentioned under the heads of Sections I and VIII.

*Magnetic observations at Philadelphia.*—To meet a request made by the Committee of the International Electric Exhibition at Philadelphia, and for the purpose of following up the secular change in terrestrial magnetism, Assistant Edwin Smith was directed in August, 1884, to determine the magnetic horizontal intensity and the dip at the building for electric tests on each of three days, the special locality to be selected after consultation with Prof. H. B. Snyder, of the Franklin Institute. He was instructed also to reoccupy the old magnetic station of the Coast and Geodetic Survey at Girard College, and to make there the usual three days' observations for declination, dip, and intensity.

After observing five sets of oscillations at the magnetic station on Capitol Hill, Mr. Smith proceeded to Philadelphia, and upon the completion of the necessary arrangements with Professor Snyder, took seven sets of oscillations and three sets of dip at the test laboratory of the exhibition on August 29, 30, and 31.

It was found that at Girard College a new station would have to be selected, the positions of the old stations being either covered with buildings or too near them to admit of obtaining results free from abnormal disturbances. At the station occupied, which was in the grounds and near the one of 1877, complete sets of observation for declination, dip, and horizontal intensity were made on September 3, 10, and 11. The true meridian was determined by four sets of observations on the sun.

The instruments used were the same as those in use for many years past by Assistant Schott at the station on Capitol Hill: Magnetometer No. 7 and Casella dip circle No. 4440. On returning to Washington, Mr. Smith observed three sets of oscillations at the Capitol Hill station.

All of the records and field computations of this work have been deposited in the office.

Other field duty assigned to Assistant Smith will be referred to under the headings of Sections VIII, IX, and XV.

*Determination of the position of a wreck off Barnegat.*—It having been reported to this office that the wreck of the steamer Guadalupe, ashore off Barnegat, was in a position dangerous to navigation, Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, was instructed to determine its position. He dispatched Ensign M. C. Gorgas, U. S. N., with orders to take the necessary measurements, and to board the wreck if practicable. By angles taken from shore stations, the position of the sunken steamer was referred to Barnegat light-house, but on account of heavy breakers Mr. Gorgas was unable to board the wreck or even get near it. As it appeared probable that the vessel would soon be broken up by the action of the sea, it was not deemed advisable to issue a Notice to Mariners.

Lieutenant-Commander Brownson reports that Ensign Gorgas carried out his instructions with zeal and intelligence under difficulties, owing to a heavy gale of wind which prevailed while crossing Barnegat Inlet and at the Light. The work was done late in November.

*Continuation of triangulation and reconnaissance on the New Jersey coast. Magnetic station occupied on that coast, and topographic survey continued.*—At the beginning of the fiscal year, Assistant Charles M. Bache was in the field on the coast of New Jersey, near Townsend's Inlet, under instructions to carry a small triangulation for the purposes of a topographical survey from that Inlet to Absecon light at Atlantic City. Subassistant J. B. Baylor was attached to his party during part of the season. He aided in the triangulation, and determined the magnetic declination, dip, and intensity at a station near Sea Isle City, on Ludlam's Beach.

Beginning with the base-line Tatham-Public, near Townsend's Inlet, Mr. Bache carried the triangulation to Absecon light, a distance of nearly twenty-seven miles, by October 15. Each station of the seventeen triangles laid out was occupied, and each angle measured by four series of observations of six repetitions each.

The stations were for the most part on the edge of the fast land of the coast and inside the sand hills of the beach. Each station was secured by a sub-surface center-mark of 7-inch gas-pipe driven into the ground.

Mr. Bache mentions that a railroad, without break except at Egg Harbor Inlet, has been constructed and is now in running order from Townsend's Inlet to Absecon Inlet, following the beach.

Mr. Baylor was relieved from duty in the party, October 1. His services are referred to in terms of high appreciation by Mr. Bache.

At the close of the season the barge Beauty, which had served as a floating camp for the party, was laid up at Sea Isle City.

During the winter, Assistant Bache completed the field computations and records of his triangulation, and at the opening of the season, in 1885, was directed to organize a party as soon as practicable and resume the topographical resurvey of the New Jersey coast. This work he began a little to the southwest of Townsend's Inlet, and at the end of the fiscal year he was steadily prosecuting it northeastwardly toward Atlantic City. Up to that date the statistics are:

Miles of outer shore-line surveyed . . . . .	5
Miles of roads . . . . .	4
Miles of shore of creeks . . . . .	40
Miles of shore of fast-land . . . . .	9
Area surveyed in square miles . . . . .	6

*Topographical resurvey of the New Jersey shore of Delaware Bay continued.*—At as early a date after the beginning of the fiscal year as the appropriation would permit, instructions were issued to Assistant R. M. Bache to resume topographical work on the east shore of Delaware Bay. The two projections, on a scale of 1-20000, furnished to Mr. Bache included the shore-line of the bay from the Hummocks, about two miles south of the mouth of Goshen Creek, to Fortescue Creek. Back of the shore-line the distance included in the survey varied from a mile to a mile and a half. The width of the belt was determined with reference to three considerations—first, the general symmetry of the circumscribed area, regarded longitudinally in view of the very great curvature of the shore; second, the exhibition within that area of the relation to each other of the intersect-

ing river and creeks; and, third, the representation within reasonable limits of the points of fast-land protruding into the wild marsh, thereby completing with other elements the characteristics of the ground. The first sheet, extending from the Hummocks to Egg Island light, was finished; the second, from Egg Island light to Fortescue Beach, was not completed when orders were received November 10 to discontinue work for the season.

Mr. E. L. Taney served as aid in the party, to the entire satisfaction of his chief.

During the winter Mr. Bache finished the inking of his topographical work, and early in June 1885, resumed field operations under instructions to take up the survey at the limit of work of the preceding season. At the close of the fiscal year he was at Nantuxent Creek, having delineated six miles of shore-line with a belt of interior topography of the average width.

The statistics for the fiscal year are:

Miles of main shore-line surveyed.....	101
Miles of shore-line of creeks.....	121
Miles of shore-line of ponds.....	20
Miles of shore-line of roads.....	33
Area surveyed in square miles.....	43

*Completion of the topographical resurvey of the western shore of Delaware Bay.*—At the opening of the fiscal year there remained on the western shore of Delaware Bay, to complete the topographical resurvey which had been in progress since 1880, a strip of topography about sixteen miles in length, extending from Clarke's Point Station, four miles north of Mispillion light-house, to Broadkill Creek, and about one mile, on the average, in width.

This work was taken up by Assistant C. T. Iardella, in pursuance of instructions dated July 12, 1884, and was finished October 31.

With regard to Mispillion Creek, Mr. Iardella observes that it is about one hundred and fifty meters (four hundred and ninety-two feet) wide at its entrance. Vessels drawing six feet can enter at very high tide, and after getting abreast of the light-house, ten to fifteen feet can be carried at low water from the light-house to Milford, a distance of twenty-one miles. In some places the creek is two hundred meters (six hundred and fifty-six feet) wide. A shoal, nearly bare at low water, obstructs the entrance; eight or nine vessels have been seen at anchor for nearly a week, waiting for fair wind and high tide, to get over the shoal.

Just below the entrance of Mispillion Creek there is a wide ditch, some two miles long, which connects with Old Cedar Creek. This creek, from its entrance to the ditch or canal, is filled up. Small vessels drawing five feet can pass through the canal, and after reaching the creek the water deepens for a short distance.

Slaughter Creek is entirely filled up at its entrance, and navigation is entirely suspended. At the entrance a shoal has been formed which for about two hundred meters is entirely bare at low tide.

The statistics of the season's work are as follows:

Miles of shore-line surveyed.....	11
Miles of roads.....	12
Miles of marsh-line.....	12
Miles of shore-line of creeks and ditches.....	11
Miles of shore-line of canals.....	7
Area surveyed in square miles.....	17

*Continuation of the hydrographic resurvey of Delaware Bay and entrance.*—As early in July, 1884, as the appropriation became available, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, was instructed to organize his party on board the steamer Endeavor, and continue the hydrography of lower Delaware Bay and entrance. For this purpose he was furnished with four projections, three of which were laid out upon a scale of 1-20000, and included areas of hydrographic work extending from the eastern and western shores of the bay north of Cape May light and Mispillion light to the main ship-channel; the fourth, on a scale of 1-40000, included hydrography in less detail between Capes May and Henlopen and off the entrance to the bay.

Great care was taken to establish a sufficient number of tide-gauges to obtain accurate planes of reference for the reduction of soundings. Box and staff gauges were fixed at the steamboat wharf, Cape May Point, and referred to a bench-mark on the beach. A box-gauge was established in the vicinity of Maurice River light-house, and referred to a bench-mark on the foundation wall of the building. Five gauges were set up near Hut Station, six miles nearly northwest of Mispillion light. These gauges were all compared with each other by simultaneous observations to guard against mishap in case of storms. They were also compared with the gauge at the United States iron pier on the Delaware Breakwater, day and night tides being observed at both places for several days.

Lieutenant Hanus, in his report of the season's work, gives full details in regard to the locality of the several gauges established, and the methods followed in obtaining comparisons of readings.

With reference to the mode of planting water signals devised by himself two years ago, and described on page 34 of the Report of 1883, he observes that a large number of these were used in the hydrographic work, and that a long tree, large at the base, was found to be better than a signal made of scantling. One of these trees, forty feet in length, was planted in fifteen feet of water. These tree pump-signals withstood every gale that occurred during the season.

Ensigns A. L. Hall, J. H. Hetherington, E. F. Leiper, and G. R. French, U. S. N., were attached to the party.

Soundings were completed according to the scheme of operations, November 12, and about a week later Lieutenant Hanus took the Endeavor to Norfolk to prepare for work on the Southern coast. Reference to this will be made under the headings of Sections V and VI.

For the Delaware Bay and entrance hydrography, the statistics are:

Miles run in sounding .....	1,530
Angles measured .....	11,022
Number of soundings .....	49,813

### SECTION III.

#### MARYLAND, DISTRICT OF COLUMBIA, VIRGINIA, AND WEST VIRGINIA, INCLUDING BAYS, SEAPORTS, AND RIVERS.

(SKETCHES NOS. 1, 4, 15, 17, AND 18.)

*Gravity determinations and experimental researches at Washington, D. C., and in Virginia.*—Instructions issued to Assistant Charles S. Peirce in July, 1884, directed him to proceed to Fortress Monroe, Virginia, to determine gravity there, and subsequently to reconnoiter for one or two stations suitable for gravity determinations in the mountain region of Virginia, West Virginia, and North Carolina.

Mr. Peirce was occupied at Fortress Monroe till about September 1 in determining the intensity of gravity. He had some difficulty in finding a suitable casemate in which to swing his pendulum, Peirce No. 3. Finally, after making some experiments with the nobby to determine the amplitude of swaying of the pendulum support (see Appendix No. 15, Report for 1884), he swung the pendulum heavy end up and heavy end down on alternate days until an ample number of oscillations had been secured in both positions. With reference to these observations Mr. Peirce remarks, "Peirce No. 3 has therefore been swung in a particularly satisfactory manner, and I consider it unnecessary to swing another pendulum here, owing to the fact of this pendulum being reversible as well as invariable. The results here will be quite as good as at Allegheny."

In September Mr. Peirce reconnoitered for a gravity station in the mountains of Virginia; but no station could be found which would meet the views of the Superintendent as to elevation above the sea-level and at the same time not be too expensive to occupy.

On returning to Washington Mr. Peirce was appointed, October 1, to the charge of the Office of Weights and Measures. The duties of this position he fulfilled till February 22, when he declined further service.

During this time, under instructions, he carried through an elaborate occupation of the initial

gravity station at the Smithsonian Institution with four reversible pendulums—"Peirce Nos. 1, 2, 3, and 4."

In November he was directed to attend the meeting at Newport of the National Academy of Sciences, of which body he is a member, and to present there a memoir upon the gravitation and other surveys. Also to attend the December meeting of the American Metrological Society and read a memoir upon the determination of gravity. This memoir will be printed by the society.

During the winter, under instructions from the Superintendent, Mr. Peirce proceeded to Boston, Providence, Hartford, New York, and Philadelphia, and conferred with the manufacturers of gauges and machinery, and also with electricians and others with reference to the resolutions passed by the United States Electrical Conference concerning weights and measures, and the best way of meeting the wants of the country. In January, 1885, he was summoned before the Congressional Commission and testified on the subject.

Towards the end of February, instructions were given to Mr. Peirce to proceed to Key West and make gravity determinations there. Mention of his operations in that locality will be made under the heading of Section VI.

*Annual determination of the magnetic declination, dip, and intensity at the station on Capitol Hill, Washington.*—In order to determine the annual effect of the secular change in the magnetic elements, observations for magnetic declination, dip, and intensity have been made at least once a year during the past thirty years at a magnetic station upon Capitol Hill, Washington, D. C. During that period, the declination has increased gradually from  $2^{\circ} 24'$  W. of N. to  $4^{\circ} 12'$ .

Assistant Charles A. Schott, by whom or under whose direction the observations have been made, observed on June 13 and 15, 1885. The secular variation of the magnetic declination in the United States and at some foreign stations was discussed by Mr. Schott in a paper published as Appendix No. 12 to the Report for 1882. In this Report will appear (Appendix No. 6) Mr. Schott's discussion of the secular variation of the magnetic dip and intensity, based upon observations made within the United States from the earliest to the present time.

*Continuation of the detailed topographical survey of the District of Columbia.*—Favorable progress has been made in the detailed topographical survey of the District of Columbia during the nine months spent by the party of Assistant J. W. Donn in field-work. This survey, made at the request of the Commissioners of the District of Columbia, and carried on since February, 1881, under their general direction, has for its main object, to quote a recent report of the Engineer Commissioner, the supplying "of data for laying out new, and extending old, roads, and for properly subdividing county property as it is laid out in suburban streets and lots.

"But its minute accuracy will make it useful for all time in planning public works of every description. It saved the necessity for the preliminary surveys in connection with the extension of the water-works now in progress, and it will accomplish the same purpose when the city sewerage has to be extended into the country. From the maps of this survey, so far as completed, and from such other data as were available, was compiled during the last year a new map of the entire District on a scale of four inches to the mile, to take the place of the Boschke map of 1855, of which the edition was exhausted, and which, in spite of many errors, was the only topographical map of the District in existence. The new map was handsomely lithographed and printed in four colors by Bien & Co., of New York.

"In connection with this survey, during the past season the four corner monuments of the District, as established by Ellicott in 1791, were identified and located. It was discovered that the District is not exactly a ten-mile square, the length of the four sides being as follows:

"Southwest 53,031.3 feet, or 231.3 feet too long.

"Southeast 52,871.3 feet, or 71.3 feet too long.

"Northwest 52,863.6 feet, or 63.6 feet too long.

"Northeast 53,063.8 feet, or 263.8 feet too long.

"The total area of the original District was 100.6 square miles. The north point is 116.6 feet west of the meridian of the south point, and the east point is 138.6 feet south of the west point. Considering the character of the instruments with which Ellicott made his survey, and the nature of the country, then practically a wilderness, through which he ran his lines, one cannot but be surprised at the accuracy of his results.

"From the data already furnished by this survey preliminary plans have been sketched out for the extension of the following avenues and streets through a portion of the county, viz, Massachusetts, Vermont, New Jersey, and Rhode Island avenues, Sixteenth street and L street. Other demands upon the District revenues make it impossible to attempt to carry these plans into effect at the present time; but the property-owners are recognizing the importance of having suburban property systematically laid out, and show a willingness to follow these plans in the subdivision of their property. By so doing the city will be saved the expense in the future of rectifying irregular street lines in the suburban district at a cost far exceeding the expenditures for this survey, which are only \$5,000 a year."

At the beginning of the fiscal year the survey had been advanced to Blagden's mill, in Rock Creek Valley, and thence along the road leading to Brightwood, and up the Seventh street road to Silver Spring and the crossing of the northeastern boundary of the District. Westward of Rock Creek Valley the work was completed from Woodley Lane at Woodley Park to the northeastern boundary stone of the new Observatory site, thence across the western extremity of Georgetown Heights to the Distributing Reservoir and to the Potomac River.

During the summer of 1884 Mr. Donn worked west of the Seventh street road, north of the Blagden mill road, and across the valley of Rock Creek above the crossing of the Military road. Much of this area was occupied by a region very difficult of access on account of heavy undergrowth. The survey was extended to the table-land lying between Rock Creek Valley and the valley of Broad Creek, and as far westward as it was possible to go during the season of foliage. This northwest corner of the District presents some great difficulties to be overcome, in the shape of almost impenetrable thickets of spruce pine covering considerable areas.

In November, after completing some work called for by the Commissioners, lying to the eastward of the Metropolitan branch of the Baltimore and Ohio Railroad, Mr. Donn transferred his survey to the country in and adjacent to the Foundry Branch Valley above Georgetown, embracing the Georgetown College grounds, and as far up the valley as Tunlaw road. The several triangulation points established along the northwest boundary line of the District were occupied, and many points determined for the needs of the survey.

During January and part of February the survey of Rock Creek Valley was completed from Blagden's mill to the crossing of the Military road, and during the latter part of February and March the valley lying immediately north of the grounds of the new Naval Observatory was surveyed from the northeast corner of that property to the Tenallytown road.

By the end of March, as there remained only enough of the appropriation to defray the cost of completing such drawings and photolithographs as were required by the Commissioners, field-work was abandoned. In April Assistant D. B. Wainwright, who had rendered most efficient service in the party, was detached for other duty, reference to which has been made under the heading of Section II. The preparation of sections of the survey for photolithographing was continued by Mr. J. A. Flemer, the draughtsman of the party. Tracings from the original sheets were prepared as needed by Mr. Donn. On the 22d of June, a small surplus having been found to be available, Mr. Donn took the field, and at the close of the fiscal year was at work extending the topography along Woodley Lane to its junction with the Tenallytown road.

*Lines of leveling of precision carried from Ashland, Va., to Fortress Monroe; also a line to connect the bench-mark near the Washington Aqueduct Bridge with the Capitol bench-mark.*—It was stated in the last annual report that the lines of leveling of precision in progress from Hagerstown, Md., towards Fortress Monroe had been carried at the close of the season in 1883 to a bench-mark established on the Duncan Memorial Chapel at Randolph and Macon College, Ashland, Va.

In pursuance of instructions issued in September, 1884, work on these lines was resumed by Assistant J. B. Weir, September 23. The Richmond, Fredericksburg and Potomac Railroad was followed as far as Richmond, Va. In passing through that city, streets were selected for the route of the levels that were least used, and at times the work was done early in the morning before any jar from heavy teams was noticeable. From the Richmond, Fredericksburg and Potomac Railroad the descent to the Chesapeake and Ohio Railroad was forty-three and six-tenths meters (one hundred and forty-three feet), although the horizontal distance passed over in the line of levels was only four and two-tenths kilometers, or two and six-tenths miles.



About three hundred meters (nine hundred and eighty-four feet) from the depot of the Chesapeake and Ohio Railroad there is a tunnel, which is fourteen hundred meters (four thousand five hundred and ninety-three feet) long; and about eight hundred meters (two thousand six hundred and twenty-five feet) from the eastern end of this tunnel is a high trestle of about the same length as the tunnel. The proximity of these two obstacles made it difficult to follow the line of the railroad, but by taking a somewhat circuitous route through streets and along the York River Railroad Mr. Weir succeeded in going round both the tunnel and trestle with but little loss of time. A point was thus reached on the Chesapeake and Ohio Railroad at the eastern edge of the city, and the line of levels was continued thence along the same road to Fortress Monroe without meeting any serious obstacle.

At Fortress Monroe the line of levels was connected with the bench-mark on the light-house, this being the bench to which the tide-gauge was referred during the period that tidal observations were made at that point. Connection was also made with a bench-mark on the fort near the postern gate, and a permanent bench-mark on the Soldiers' Home in Hampton.

Full descriptions of these bench-marks accompany the records and computations which have been transmitted to the office. The field computation will require to be checked by the office computation before an accurate comparison can be made between the tidal levels at Sandy Hook and Fortress Monroe.

After finishing the work just referred to, Mr. Weir, under instructions, ran a line of levels to connect the bench-mark near the Washington Aqueduct Bridge with the Capitol bench-mark.

Mr. John Nelson served as acting aid in the party very acceptably.

Other lines of leveling of precision run by Mr. Weir during the spring of 1885 will be referred to under the heading of Section XIV.

*Determination of points on the boundary line between Maryland and Virginia.*—Application having been made by the Governors of Maryland and Virginia for the detail of an officer of the Coast and Geodetic Survey, who should mark and determine in geographical position two points on the boundary line between their respective States, in the presence of Mr. William J. Aydelott, Commissioner on the part of Maryland, and Mr. George H. Bagwell, Commissioner on the part of Virginia, instructions were given November 17, 1884, to Mr. Charles Junken, Acting Assistant, to meet the commissioners for the purpose just indicated.

On December 1, the steamer Governor McLane, under command of Capt. H. Thompson, of the Maryland fishery force, was placed at the disposal of the Commissioners, and was retained by them until the weather became so stormy and inclement that they deemed it advisable to postpone the completion of the work till spring, only five working days having been obtained between December 1 and 23.

The points to be marked were in Pocomoke Sound, at a distance apart of two and a half miles (nautical), and in seven and twelve feet water, respectively. From three shore stations, known in position, Mr. Junken established two groups of permanent range marks, each group having two front signals and one rear signal; these signals were placed on the north shore of the sound, one group to the east, the other to the west of Apeshole Creek. By means of the range signals the places of the two points on the boundary line were readily found, and marked temporarily with quarter inch iron pipe.

In May 1885, Mr. Junken again met the commissioners to complete the work. At the most southern point in the line, about two and a half miles (nautical) from the mouth of Broad Creek, he anchored a third-class can buoy in eleven feet water, soft bottom. The buoy was painted white, and was secured by a second-class stone sinker with fifteen fathoms of chain. This was done on the 20th of May, and on the same day a six-inch galvanized iron pipe thirty feet long, with steel driving-point, was sunk nineteen feet into the ground, in seven feet of water, at the more northern point in the line, about a mile and a half (nautical) west of the entrance to Pocomoke River. At this point the bottom is of soft mud, with a hard top-crust of sand and gravel of two feet in thickness. To the top of the pipe is secured a cap made of hoop-iron, forming a skeleton sphere of sixteen inches in diameter, with the letters "MD." "VA." attached.

For the front and rear range signals underground marks were placed in position.

Before returning to the office, Mr. Junken determined trigonometrically the positions of

James Island light and Somers Cove light. In his report he expresses his thanks to the Commissioners and to Captain Thompson for their uniform courtesy.

*Hydrographic examinations off Cape Henry, Virginia.*—Upon the completion of hydrographic work in Long Island Sound, which has already been referred to under the heading of Section II, Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner *Ready*, was directed to proceed to Cape Henry, Virginia, and make an examination of the shoal upon which the U. S. S. *Ossipee* grounded. The soundings as given on the chart, he was to connect with the shore-line, and continue examinations south of the cape.

This work was completed by Ensign Fechteler about the middle of December, though only by great persistence in the midst of frequent interruptions from stormy weather. No changes were found of sufficient importance to involve alterations upon the chart.

*Supplementary topographical survey between Norfolk and the ocean shore.*—Some details of topography yet remaining to be completed between Lynnhaven River, Virginia, and the sea-coast, in furtherance of this work Assistant Eugene Ellicott was sent to Norfolk towards the end of November, 1884. The season proved unfavorable; cold, wet, and stormy weather in December retarded field operations, and early in January the party was disbanded. Mr. Ellicott reports thirteen miles of roads surveyed, and an area of thirteen square miles. Mr. J. H. Gray was attached to the party as aid.

Towards the end of April, 1885, Mr. Ellicott resumed this work under instructions and completed it on the 19th of May.

Other surveys made by Mr. Ellicott are referred to under the headings of Sections I and VI.

*Extension of the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio.*—At the beginning of the fiscal year Assistant A. T. Mosman was in the field making the needed preparations for extending the primary triangulation westward near the thirty-ninth parallel from the points previously occupied by him in West Virginia. On the 16th of July, 1884, he established his camp at Station Wray, in Lawrence County, Ohio, about sixteen miles east of Ironton.

At this station an observing tripod had been erected eighty feet in height. Heliotropes were posted at Stations Davis, in West Virginia, and Oakland, in Kentucky, and the signal at Gebhardt, West Virginia, was visited and verified; but, owing to unfavorable weather, no observations were obtained till August 5. Meantime, it having been found that the line Wray-Buena Vista was not practicable on account of an intervening ridge, a change of scheme of triangulation became necessary, and after finishing observations on the stations to the eastward a reconnaissance was begun August 21, and the country between Wray and Buena Vista thoroughly explored. At the beginning of this reconnaissance, and in the observations preceding, Mr. Mosman had the skillful and energetic aid of Prof. J. H. Gore, of the Columbian University, who served in the party as volunteer assistant from August 6 to August 23.

A point called Tradd was finally selected on the ridge to the westward of Wray. From Tradd five of the primary stations were visible. Mr. Mosman returned to camp September 1. During his absence Mr. J. E. McGrath, aid, had reported for duty. By September 6 the angles remaining had been measured at Wray, and on the 7th the theodolite was mounted at Gebhardt Station, in Cabell County, West Virginia, about twenty miles north of Huntington. The direction from Gebhardt to Tradd was quickly determined, and on September 9 preparations were begun for occupying Station Oakland, Boyd County, Kentucky, six miles south of Catlettsburg.

At this station the theodolite was mounted upon a tripod forty-five feet high. A similar tripod was erected at Tradd by E. E. Torrey, foreman, and the line between Oakland and Tradd was opened by Mr. McGrath. Observations at Oakland were begun September 16. Mr. P. A. Mosman, who acted as recorder from the beginning of the season, left September 25, and Mr. W. B. Fairfield, extra observer, reported for duty on the same day. Work at Oakland was finished October 2, and preparations were then begun for moving to Buena Vista, about sixteen miles south of Greenup, Ky., in the county of that name. While the moving was in progress Station Tradd was occupied by Extra Observer W. B. Fairfield, who measured approximate angles there with an eight-inch theodolite on Oakland, Buena Vista, and Wray.

At Buena Vista the large theodolite (No. 118) was mounted on a concrete pier October 12.

H. Ex. 18—6

Signals of sixty-five feet at Howland Station, and thirty feet at Cave Station had been erected and heliotropers posted. By October 23 all of the observations needed at Buena Vista had been obtained. The camp equipage was then stored at Franklin Furnace; the party disbanded, a driver only being retained, and preparations were made for continuing the reconnaissance to the westward.

As the country through which it was carried—the counties of Scioto and Adams, Ohio, bordering on the Ohio River—is very broken, thinly inhabited, and with but very few roads, much difficulty was experienced in carrying on the work. It was found necessary to erect a tripod and scaffold one hundred feet high at Scioto Station, about four miles northwest of Portsmouth. On November 10, reconnaissance angles were measured from the top of this tripod. Meanwhile a station on Cherry Ridge, back of Concord, Ky., had been selected. This point occupied a commanding position, giving a very fine view to the northward and westward.

The weather continuing unfavorable, Mr. Mosman, after examining the difficult country between the headwaters of Blue Creek, Churn Creek, and upper and lower Twin Creeks for a central station decided to make a general examination of the country between Rome, on the Ohio River, and West Union, the county seat of Adams County, which is situated on a high ridge and occupies the highest ground in the vicinity. From the top of a lofty building in this town, a ridge near Mineral Springs, Ohio, was found to be the most commanding position from which to see Scioto, Cherry Ridge, and the hills at the head of Twin Creek.

Mineral Springs was visited November 22, and between that date and December 22 the reconnaissance was steadily prosecuted by Mr. Mosman, much of the time through a heavily-wooded country, crossed by ridges of nearly equal height, and with not a few interruptions from snow-storms and intensely cold weather, with high winds. His report of the work is accompanied by a sketch showing the scheme of triangulation found most practicable.

In addition to the two gentlemen already referred to as having served in the party, Assistant F. D. Granger was attached to it from September 26 to October 6. Extra Observer W. B. Fairfield was ordered to the party July 1, but owing to illness was unable to take the field till September 25. He was detached November 10. Mr. P. A. Mosman served as recorder till September 25, acting also for a time as foreman in moving and pitching camp, posting heliotropers, &c.

Mr. Mosman refers in terms of cordial appreciation to the interest in the work taken by the officers of his party and to their constant and zealous efforts for its advancement. He acknowledges also the efficient labors of his foreman, E. E. Torrey.

Statistics of the season are:

Primary stations occupied .....	4
Observing tripods and scaffolds erected (heights of 30, 45, 65, 100 feet) .....	5
Primary stations selected in reconnaissance .....	5
Number of primary objects observed .....	20
Number of observations on primary objects .....	1548
Number of secondary objects observed .....	2
Number of observations on secondary objects .....	13

The records of the work, original and duplicate, and the field computations have been transmitted to the Office.

## SECTION V.

SOUTH CAROLINA AND GEORGIA, INCLUDING COAST, SEA-WATER CHANNELS, SOUNDS, HARBORS, AND RIVERS. (SKETCHES NOS. 1, 5, 17, AND 18.)

*Hydrographic survey in the Stono and Wadmelaw Rivers, South Carolina.*—Some additional soundings being required to develop the hydrography of the inland passages which connect Charleston Harbor and North Edisto River, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Arago, was directed to execute this work. The Stono and Wadmelaw Rivers are in many places very narrow and full of shoals, and it was found necessary to take soundings rapidly. As but three points of the old triangulation could be found near one end of the work, and but two at the other, it became necessary to lay out a small triangulation. This closed exactly upon the old points.

To obtain a well-determined plane of reference for the soundings, five tide-gauges were established between Martin's Point on Wadmelaw River and Elliott's Cut, Stono River, a distance of nine teen miles. As no station could be occupied during a lunar month, all gauges were compared with the self-registering gauge of the United States Engineers at Fort Sumter, where consecutive tides had been observed for a year or longer.

Lieutenant Hanus had the aid of the following named officers: Ensigns E. F. Leiper, F. R. Brainard, and George B. French, U. S. N.

In March, 1885, the hydrography was completed and the following statistics reported:

Miles run in sounding .....	214
Angles measured.....	3, 335
Number of soundings.....	30, 899

Early in April, in pursuance of instructions, Lieutenant Hanus took up hydrographic work on the Saint John's River, mention of which will be made under the heading of Section VI.

## SECTION VI.

PENINSULA OF FLORIDA, FROM SAINT MARY'S RIVER, ON THE EAST COAST, TO AND INCLUDING THE ANCLOTE KEYS ON THE WEST COAST, WITH THE COAST APPROACHES, REEFS, KEYS, SEA-PORTS AND RIVERS. (SKETCHES Nos. 1, 6, 7, 17, and 18.)

*Triangulation and shore-line topography of Saint John's River, from Nine-Mile Point to Palatka.*—In continuation of the survey of the Saint John's River, Florida, Assistant Eugene Ellicott was directed to proceed to Jacksonville, Fla., and await there the arrival of the schooner Ready. In March, 1885, he sailed to Nine-Mile Point, about twenty miles below Palatka, and began a triangulation of the river. Upon the 17th of March this work was finished to the Devil's Elbow at the head of the broad easily navigated part of the river, and about two miles above Palatka. The shore-line topography was then taken up and carried over the same ground. It was deemed desirable to postpone filling in details of topography in view of the expected early arrival of the hydrographic party. Mr. Ellicott states that the Saint John's is navigable for ocean steamers to San Mateo, eight miles above Palatka, and that he thinks they go still further up when freights are offered. Traffic on the river is large, and the demand for a chart of the portion then under survey very great. From the entrance to Racy's Point, just above Nine-Mile Point, a chart of the Saint John's has been published in four sheets.

Much of the shore-line survey had to be done with the plane-table standing in from one to two and a half feet of water, and certain parts of the shore line are outlined only by an edge of cypress trees, the water extending back for an apparently indefinite distance. From the Devil's Elbow, a sextant triangulation was carried, and an approximate shore line delineated as far as San Mateo.

On the 15th of April Mr. Ellicott, in accordance with instructions, turned the Ready over to Lieutenant Hanus, U. S. N., Assistant Coast and Geodetic Survey, and the next day proceeded northward.

Duty subsequently assigned to him has been referred to under the headings of Sections I and III.

*Hydrographic survey of Saint John's River from Racy Point to Palatka.*—Upon the completion of the triangulation and shore-line topography of the Saint John's River between the limits mentioned under the previous heading, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Arago, began a hydrographic survey extending from Racy Point (just above Nine-Mile Point) to San Mateo, about four and one half miles (by the river) below Palatka. On the 16th of April, Lieutenant Hanus was detached from the party for other duty, and in pursuance of instructions transferred the command of the Arago to Ensign E. F. Leiper, U. S. N., Assistant Coast and Geodetic Survey, under whose direction the work was completed.

At the beginning of the survey, the river was almost two miles wide, and lines of soundings about three hundred meters (nine hundred and eighty-four feet) apart were run as nearly normal to the shore as practicable. As the width of the river decreased the lines of soundings were run closer.

The time allowed for the work being very short, no attempt was made to sound out the creeks;

only two of these, however, were navigable, Deep Creek and Rice Creek. A sextant triangulation having been made in advance by the topographical party, and an approximate shore line determined as far as San Mateo, the hydrography was completed to that point.

A plane of reference for the soundings was determined by observations with a box-gauge secured to one of the piles of the wharf of the Tropical Hotel at Palatka. Tides were observed during thirteen days and twenty consecutive low waters taken. A bench-mark was established on the post of piazza of the hotel. The mean rise of tides observed was nine-tenths of a foot.

Ensign Leiper had the aid of Ensigns F. R. Brainard and G. R. French, U. S. N. He reports the following statistics of the survey:

Miles run in sounding .....	252
Angles measured .....	3,154
Number of soundings .....	17,574

Before the work was finished Ensign Brainard was sent north in charge of the schooner Ready, which had been turned over by the Assistant in charge of the topographical party. Ensign Leiper was directed to proceed to New York upon the completion of his survey and report for duty on board the steamer Endeavor.

*Deep-sea soundings in Northwest Providence Channel and in the Gulf Stream off Florida coast, and subcurrent observations in the Gulf Stream between Fowey Rocks and Gun Cay, Bahamas.*—Early in December, 1884, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, was detached from duty in the office of the Hydrographic Inspector and directed to proceed to New York and relieve Lieut. Commander W. H. Brownson, U. S. N., Assistant in the Survey, of the charge of the steamer Blake and hydrographic party aboard that vessel. Under Lieutenant Pillsbury's command, the Blake was brought to Washington in pursuance of additional instructions, and fitted for deep-sea sounding and current work off the Florida coast.

The Blake left Washington February 6, 1885, and arrived at her working ground February 18. She left the Florida coast at the close of the season, June 2, reached Charleston, S. C., June 4, and convoyed the Coast and Geodetic Survey steamer Arago north.

Lieutenant Pillsbury has submitted a full report (Appendix No. 14) of his season's work, which was a remarkably successful one. Five lines of soundings were run in the Gulf Stream to the southeast of Cape Canaveral, two lines of soundings across the stream between Cape Florida and Jupiter Inlet, and three lines in Northwest Providence Channel between Bahama Island, Great Abaco, and Great Bahama Bank. Tidal observations were made during six weeks with a box-gauge established at the Fowey Rocks light-house.

Seventeen stations were occupied for current observations in the Gulf Stream between Fowey Rocks and Gun Cay, Bahamas. For the observation of subcurrents a current meter was invented and constructed by Lieutenant Pillsbury. One of the conditions of the successful use of this meter was that the steamer should be safely and expeditiously anchored at sea. For this purpose a steel wire rope of five-eighths and three-fourths of an inch in diameter was used instead of chain or manilla. This wire rope was carried on a large reel and led from that to the drum of the hoisting engine, and from thence through a large iron pulley at the end of a spar over the bow. This spar was hinged at its inner end to a heavy post in the bow and its outer end was held up at an angle of forty-five degrees by a steel wire rope or topping lift, leading over the masthead and to the deck aft. Interposed in this topping lift was an arrangement of rubber buffers, about eight feet in length, designed to take up the slack and relieve the sudden strain on the anchoring rope as the vessel pitched. With this gear the Blake could be anchored in four hundred fathoms in about fifteen minutes, and could get under way in about forty-five minutes.

The current meter consisted of (1) a system of cones revolving around an axis, and registering by means of differential wheels; (2) a freely moving rudder; (3) a compass; (4) an arrangement of wings or fins by which the compass needle and rudder are clamped at the instant of beginning to pull the meter upward through the water; and (5) a propeller which locks the needle and rudder after they have been clamped by the fins, by a continuation of the upward movement.

The meter was lowered by a steel wire, and, in order to keep it from being swept astern by the current, it was attached by a roller to another wire called a jackstay, down which it was free to move. This jackstay wire was anchored on the bottom and kept up and down by weights.

Lieutenant Pillsbury states that the meter worked well, and believes that its results may be accepted with confidence.

The plan proposed for the season's work was to take a series of current observations with soundings at stations between Gun Cay, Bahama Banks, and Fowey Rocks, Florida, followed by a similar series between Yucatan and Cuba, and then to repeat the first series.

Results derived from the first series seemed to indicate that tidal action was more marked than had been supposed; that the axis of the stream was not where it had been put by the old observations, and that the greatest velocity was at or very near the surface.

These results led Lieutenant Pillsbury to ask that his original instructions should be modified so as to confine the current observations to the Florida cross-section. Five principal current stations were accordingly occupied between the Fowey Rocks and Gun Cay. These stations were at about equal distances from each other and from the land on either side. Four of them were occupied during periods of from forty to seventy hours each, and one, situated about eight miles from Fowey Rocks, over four hundred hours.

Quoting from Lieutenant Pillsbury's summary report:

"The record shows, first, that there is a diurnal variation in the velocity of the stream, amounting in some instances to nearly two knots, and that this variation extends to the subcurrents as far as observed (one hundred and thirty fathoms).

"Second. That there is a monthly variation in the velocity, amounting to about three knots, with the conditions of the sun and moon both having great declination.

"Third. That the axis of the stream at this portion of it is probably not in the position supposed by Professor Bache, but is situated more to the westward. The exact position could not be determined in the time allotted to the work.

"Fourth. That the direction of the upper currents, at three and a half, fifteen, and thirty fathoms, remained approximately north. The sub-currents at sixty-five and one hundred and thirty fathoms changed somewhat in direction with the diurnal variation in velocity, often as much as five points on either side of the meridian, and in one or two instances at one hundred and thirty fathoms the rudder indicated a southerly current. This, however, was at the shoaler anchorage, two hundred fathoms in depth, and with a velocity of but a tenth or two, and it is possible that with such a weak current the instrument was in error, although there was no evidence that such was the case.

"Fifth. That the velocity of the subcurrents was in some instances greater than that of the surface current, but the mean of about an equal number of observations on the principal stations, as well as the mean of all the observations on the long station, showed a less velocity in the subcurrents. A continuation of the vertical curves below the point of the greatest depth observed seems to indicate that there is no current at the bottom, but this conclusion may be changed by a complete discussion of the observations on some of the stations."

These results are of great interest as a contribution to our knowledge of the currents of the Gulf Stream, and similar observations carried through another season with the experience gained by Lieutenant Pillsbury will add to their value.

The following named officers were attached to the *Blake*: Ensigns A. F. Fechteler, P. J. Werlich, W. A. Thom, William Truxtun, E. Simpson, and M. C. Gorgas, U. S. N.

The statistics of the season are reported as follows:

Miles run in sounding .....	577
Number of soundings.....	152
Number of specimens of sea-bottom preserved .....	87
Current stations occupied.....	17
Total number of current observations with the current meter at depths of two, three and a half, fifteen, thirty, sixty-five, one hundred and thirty, and two hundred and ten fathoms .....	1,059
Total number of surface observations .....	2,326
Greatest depth of anchoring at any station .....	470 fathoms..
Least depth of anchoring at any station .....	200 fathoms..
Number of current bottles thrown overboard .....	48

While at Key West, in March, 1885, Lieutenant Pillsbury rendered an important service to the steamer *Alamo* of the Mallory line, which had run ashore on Southwest Reef, Tortugas, in a very dangerous position. Learning this, he went at once to her assistance, and although the light-house tender *Laurel* was already doing her utmost to get the *Alamo* off, and the *Blake* aided the *Laurel* in towing at high water, their united efforts were unavailing during five trials. An anchor was then planted on the port bow of the vessel to haul it to windward, and on the sixth trial the revenue steamer *Dix*, which had arrived to render aid, hauling on the port quarter, and the *Laurel* and *Blake* pulling astern, the *Alamo* came off practically uninjured. In the work of relief the deep anchoring gear of the *Blake* was of great service.

At the close of the season the *Blake* was taken to Hampton Roads, and thence to Boston, to be prepared for work on the New England coast. Duty on that coast, assigned to Lieutenant Pillsbury at the beginning of the fiscal year, has been already referred to under the heading of Section I.

*Determination of gravity at Key West.*—Towards the end of February, 1885, in pursuance of instructions, Assistant C. S. Peirce proceeded to Key West, Fla., to determine the intensity of gravity. Authority having been obtained from the Secretary of War, a station was selected in the barracks at Key West. Pendulum No. 2 was set up and oscillated, heavy end up and heavy end down. The usual transits for time were observed. Mr. Peirce has reported as a preliminary result from his field computations that gravity is in excess on Key West relative to Washington by an amount producing 1".46 error in a clock per diem.

Field operations were completed at Key West station by the 1st of May. Mr. W. B. Fairfield, extra observer, took part in all of the observations. In his report Mr. Peirce speaks in terms of the highest commendation of Mr. Fairfield's services.

Referring to the fact that the residual difference of gravity between Washington and Key West is somewhat smaller than he had anticipated, Mr. Peirce expresses the opinion that the question to which gravity research should be directed more particularly for the present is, whether lines of equal residual gravity can be traced upon the map, or whether the merely local variations will mask those that are progressive, and that for this purpose lines of stations a thousand miles or so in length should be run with stations three degrees apart. But that a north and south line will never afford so clear a proof of the existence of progressive variation in the residual gravity as an east and west one, because with the former there would always remain a doubt whether the assumed latitude correction was right for this part of the world, and though its being different in different parts of the globe would necessarily imply progressive variation along the circles of latitude, yet that might be so slow as not clearly to show itself, say in a thousand miles, without which curves could hardly be drawn. The first endeavor should therefore be to run an east and west line.

*Beach measure and topography on the west coast of Florida from Bowditch Point to Cape Romano.*—In continuation of the survey of the west coast of Florida, from the vicinity of Punta Rasa towards Cape Sable, Assistant Joseph Hergesheimer was directed to organize his party for beach measure and topography on board the schooner *Quick*.

The *Quick* was got ready for sea at as early a date as practicable, and reached Punta Rasa, with Mr. Hergesheimer and party on board, December 18, 1884.

The topography of the beach and inlets was begun at Bowditch Point, about three and a half miles south of Punta Rasa, and was completed to Wiggins Pass, a distance of about twelve miles, by December 26. Leaving Punta Rasa on the 29th, Mr. Hergesheimer anchored the schooner the next day in Big Marco Pass, and began the beach measure and topography from Wiggins Pass to Cape Romano, thirty-three miles.

As determined by this work, the geographical position of Cape Romano is a preliminary one, but sufficiently correct for topographic or hydrographic purposes. From Caximbas Pass to Cape Romano the distance was carefully measured twice with a twenty-meter chain.

Unusually stormy weather prevailed during the season, there being a succession of northers with lower temperatures than had been known in that locality for many years. Field operations were closed March 28.

Before leaving the field, Mr. Hergesheimer furnished Lieutenant Heald, commanding the

steamer *Bache*, with the geographical position of the points needed for his hydrographical work on that coast.

The *Quick* was laid up in Manatee River, in charge of a competent ship-keeper, at the close of the season.

Mr. J. Henry Turner, Aid, joined the party January 27, and rendered efficient service during the remainder of the season.

Mr. Hergesheimer states that the only anchorages for a vessel drawing between five and eight feet of water between Punta Rasa and Cape Romano are Big Carlos and Big Marco Inlets. Big Marco is a good harbor; there are from eight to ten feet of water on the bar, and the channel was wide enough for the *Quick* to beat in.

The statistics are:

Points determined .....	77
Angles measured .....	124
Number of observations .....	1,057
Number of miles of beach measurement .....	33
Miles of coast line surveyed with adjacent topography ..	41

Duty assigned to Mr. Hergesheimer later in the year is reported under the heading of Section II.

*Hydrographic survey of the west coast of Florida from the vicinity of Gordon's Pass to Cape Romano.*—Upon being relieved from the command of the schooner *Eagre*, towards the end of November, 1884, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, was directed to take command of the steamer *A. D. Bache*, and prepare her for service in southern waters. A month later, a hydrographic party having been organized on board the *Bache*, and the vessel having been made ready for sea, Lieutenant Heald received instructions to execute hydrographic work on the coasts of Alabama and Louisiana and on the west coast of Florida. The first named work having been completed, the *Bache* arrived off the Florida coast early in May, 1885, and began the hydrographic survey from the southern limit of Lieutenant Mansfield's work in 1884, near Gordon's Pass. Lieutenant Heald's survey was based upon points determined and shore line furnished by Assistant Joseph Hergesheimer, then at work on that coast. From Gordon's Pass to Cape Romano, the southern limit of Lieutenant Heald's survey, ship lines of soundings were run one mile apart to develop the ten-fathom curve, and from the boats lines were run one-quarter of a mile apart to develop the three-fathom curve.

Information having been received at this office from Mr. P. L. Cosgrove, master of the light-house tender, *Laurel*, of the existence of an uncharted reef between Marquesas Rock and Coal-Bin Shoal, Lieutenant Heald was directed to examine the locality. He found a shoal on a line joining Marquesas Rock with Coal-Bin Shoal, and on the following bearings:

Marquesas Rock, west one and a quarter miles.

Coal-Bin Shoal, east five and three-eighths miles.

Western extremity Marquesas Keys, north one-half east six miles.

The least water found was sixteen feet. It is situated on the crown of the Florida Reefs, and is named Cosgrove Shoal, after the person who first announced it.

A notice to mariners was issued, reporting the result of Lieutenant Heald's examination. In this, as in similar notices issued by this office, all bearings are magnetic, all distances in nautical miles, and all depths at mean low water.

Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N., were attached to the party.

Statistics of the work off the Florida coast are:

Miles run in sounding .....	511
Angles measured .....	804
Number of soundings .....	8,744

Towards the end of May Lieutenant Heald proceeded north in the *Bache*, under instructions to prepare for work on the coast of Maine.



## SECTION VIII.

ALABAMA, MISSISSIPPI, LOUISIANA, AND ARKANSAS, INCLUDING GULF COASTS, PORTS, AND RIVERS.  
(SKETCHES Nos. 1, 5, 8, 17, and 18.)

*Continuation of reconnaissance for the connection of the triangulation of the Gulf coast with that along the Blue Ridge.*—Reference was made in the last annual report to a reconnaissance carried southwesterly from stations in Northern Alabama by Assistant O. H. Tittmann, under instructions to ascertain the most practicable route for extending the Blue Ridge triangulation to the Gulf of Mexico. In November, 1884, Assistant Tittmann was directed to resume this work, and to begin in the vicinity of Mobile. His plan was to examine in detail the country in the immediate vicinity of that port, to reconnoiter the valley of the Alabama River, and to continue the selection of points in the more northern portion of the State, determining the geographical positions of these points with some accuracy.

Leaving Washington December 4, Mr. Tittmann began his reconnaissance at Spring Hill, six miles west of the city, having previously had a consultation with Prof. Eugene A. Smith, State geologist. Professor Smith's knowledge of the country to be traversed enabled him to communicate valuable information which was most freely and courteously accorded.

An examination of the Alabama River as far as Selma was made, and notes taken of the country, as also of localities near Mobile and in the vicinity of Mount Vernon, the site of the United States barracks of that name, thirty miles north of Mobile. There is a crest of hills at this point rising to a height of about one hundred and eighty feet above tide-level. On the eastern side of the river the hills attain a height of about three hundred feet. On both sides they are covered with heavy growths of pine. Mr. Tittmann reports that the most feasible method of conducting the work from Mobile to Choctaw Bluff in Clark County, a distance of fifty miles, would be by a scheme of triangulation involving long lines on the west side, and forming the bases of overlapping triangles, the sides of which would be carried by diagonals to points across the river. Quadrilaterals could doubtless be formed if time enough were given for the selection of the points.

Mr. Tittmann resumed the reconnaissance in the northern part of the State about the middle of February, and has submitted a sketch showing the plan of a proposed triangulation. Much delay was occasioned by the unusual dryness of the season, which caused an accumulation of smoke from the burning of brush and leaves in the woods. At the beginning of May, field operations were closed.

Mr. George F. Bird served efficiently as aid in the party. Early in June, Mr. Tittmann was assigned to duty, reference to which has been made under the heading of Section II.

*Hydrographic work in Mobile Bay and around the Chandeleur Islands.*—An examination of the newly dredged channel in Mobile Bay having become necessary in order to correct the published charts of that locality, and it being desirable to ascertain the nature and extent of other changes reported to have taken place in the bay, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, was instructed to organize a hydrographic party on board the steamer A. D. Bache for the execution of that work.

The dredged channel varies in width from one hundred and fifteen feet to two hundred feet, and in depth from fifteen and a half to twenty-two feet. It extends from the city of Mobile to the Lower Fleet in Mobile Bay, and is indicated by clusters of piles, fifty-one in number, one half a mile apart on the eastern side, the center of the channel being one hundred feet west of the line of piles. In March, 1885, Lieutenant Heald began his survey by determining the direction of this channel and the positions of the beacons and clusters of piles which are intended as permanent "aids to navigation."

All of these were located and plotted upon the projection. Lieutenant Heald states that it is the intention of the Light-House Board to place a light at the south entrance in the position of Cluster No. 51.

The lower portion of the channel, where the least depth is found, is now being redredged, and will soon have a depth of eighteen feet. Owing to the nature of the bottom, which is a soft

mud, great difficulty is found in keeping a permanent depth. The tendency in the upper part of the channel is to deepen it.

Quite rapid and important changes have taken place in the topography at the mouth of the bay. Pelican Island has completely disappeared, leaving only a small shoal with one to two feet water upon it. East and West Sand Islands have been connected, and the single island thus formed is gradually extending to the northwest. Two new islands, named, respectively, Coffee and Dixie, have been formed on the sand-banks on the east side of the entrance, and are about one foot above high water. All of these changes were carefully located on the hydrographic sheet.

Upon closing work in Mobile Bay, April 6, Lieutenant Heald proceeded under instructions to the Chandeleur Islands to fill in certain details of hydrography to the eastward of those islands and in Chandeleur Sound. This work was finished April 29, at which date Lieutenant Heald left for the coast of Florida to make a hydrographic survey, of which mention has been made under the heading of Section VI.

The following named officers were attached to the *Bache*: Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N.

Statistics of the work are as follows:

Miles run in sounding .....	848
Angles measured .....	2,371
Number of soundings .....	20,283

*Determination of the longitudes of Little Rock, Texarkana, and Fort Smith, Ark.*—In March, 1885, instructions were issued, organizing three longitude parties for the ensuing season, two of these parties for the determination of primary stations and one for secondary.

Assistant Edwin Smith was placed in general charge of the work; Assistant C. H. Sinclair was assigned to the charge of the subparty for primary determinations, and Subassistant E. D. Preston was detailed in charge of the subparty at secondary stations.

The plan of operations included the determination of three stations in Arkansas, one of them Little Rock, a primary station, and two others, Texarkana and Fort Smith, secondary. At Fort Smith and Texarkana observations were to be made for latitude also.

By the middle of April Mr. Smith was at Galveston, Tex., the initial point from which Little Rock was to be determined. At the latter station Assistant Sinclair established a temporary observatory. Continuous bad weather for upwards of ten days delayed the beginning of the work. Exchanges of telegraphic signals were obtained on the nights of April 28 and 30, May 3, 4, 6, and 9, but of these the nights of April 28 and May 4 were imperfect. The observers then changed places, and, Mr. Smith being at Little Rock and Mr. Sinclair at Galveston, the longitude determination was completed by exchanges obtained on the nights of May 12, 14, 15, and 21.

The next determinations made were those of Kansas City, Mo., and Texarkana, on the boundary line between the States of Texas and Arkansas. That of Kansas City will be referred to under the heading of Section XV. For the longitude of Texarkana signals were exchanged between Assistant Smith at Little Rock and Subassistant Preston at Texarkana. This being a secondary station, the observers did not change places. Longitude signals were successfully exchanged on the nights of May 30, 31, June 1 and 2. Mr. Preston determined the latitude of his station, connected its position with that of the ninety-eighth mile-stone north of the Sabine River on the boundary line between Texas and Arkansas, and established a meridian line for the city engineer.

He then proceeded to Fort Smith, Ark., from which point he exchanged longitude signals with the observer at Little Rock, Mr. Sinclair, who had exchanged stations with Mr. Smith. The exchanges of signals for longitude between Messrs. Smith and Sinclair will be referred to under the heading of Section XV. With Little Rock exchanges of longitude signals were obtained on the nights of June 12, 18, 19, and 20. Mr. Preston determined the latitude of his astronomical station, and connected it in position with the stone monument which marks the line between the State of Arkansas and the Choctaw Nation (Indian Territory). This monument is called "Initial Point," and all miles on the State line count north and south from it. A meridian line was also established for the City Engineer.

Upon the completion of work at Fort Smith, Mr. Preston proceeded under instructions to

Kansas City, Mo., in order to observe for personal equation with Messrs. Smith and Sinclair. Further mention of this work will be made under the heading of Section XV.

*Triangulation and topography of the coast of Louisiana from Côté Blanche Bay to the westward.*—In February, 1885, Assistant F. W. Perkins was instructed to proceed to New Orleans and fit out the steamer Hitchcock for the purpose of continuing the triangulation and topography of the coast of Louisiana from Côté Blanche Bay to the westward. It had been supposed that some points of the old triangulation, executed previous to 1861, might be found, but this proved to be not the case. Owing to the very soft and yielding nature of the marshy shores of the bay, all of the old marks had disappeared.

A base line about two and one-eighth miles in length, was accordingly measured near the Southwest Pass of Vermillion Bay, and from this a new triangulation was made to establish points for the topography. It was only by the greatest care that moderately good results could be obtained. The local term "floating turf" well describes the unstable nature of the marshy shores. They are subject to constant change, and the preservation of the station marks is thereby rendered doubtful.

Field operations were closed May 20, at which date the following statistics of the work are reported:

Area covered in square miles by triangulation .....	400
Number of stations occupied .....	16
Number of positions determined .....	31
Miles of shore line of topography run .....	30
Area of topography in square miles .....	24

Mr. Perkins speaks in terms of high praise of the untiring efforts of Mr. E. L. Taney, who served as aid in the party, and Mr. Richard C. Wilson, of Mobile, who volunteered to do duty as cadet-engineer and clerk, serving without pay. He expressed his many obligations to Mr. Avery, the proprietor of Petit Anse Island, and to Major Crooks, the superintendent of the salt-works there, for their courtesy and the material assistance rendered by them to the work. Also to Messrs. Netlie and Kock, of the Morgan steamship line, for facilities kindly offered in securing the Hitchcock for the summer.

Other duty assigned to Mr. Perkins has been referred to under the headings of Sections I and II. In the latter part of the summer and early in the autumn of 1884, he was engaged in some experiments for the improvement of the lights used as night-signals in geodetic work. These experiments were so far successful as to increase the available amount of light-rays from about twenty-five to two hundred candle-power. This was accomplished by a simple arrangement of reflectors which did not involve any material increase in the amount of combustion. With more time at his command, Mr. Perkins hopes to present a form of apparatus wholly satisfactory and practical. He expresses his indebtedness to Joseph Funck, foreman of the lamp shop of the Light-House Establishment, who, by permission of General Duane, Engineer of the Third Light-house District, rendered essential aid in conducting the photometrical observations and arranging details of construction.

*Hydrographic survey off the coast of Louisiana from Sabine Pass eastward.*—In continuation of the hydrography of the coast of Louisiana from Sabine Pass eastward, Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey, was instructed, in December, 1884, to complete the fitting of the steamer Gedney for sea, and proceed at as early a date as practicable to Sabine Pass.

Upon reaching that locality at the beginning of March, Lieutenant Crosby established his principal tide-gauge for the season on Dorman's wharf at Sabine Pass. This gauge, a simple staff nailed to the wharf piling, its numbers increasing with rise of tide, was observed continuously from March 10 to June 5. A second gauge was located at the mouth of the Calcasieu River, and observed during three days. Owing to the freshets in the river during the spring season it was found impossible to establish a plane of reference by observation, but through the courtesy of the United States Army engineers engaged in constructing jetties on the bar at Sabine Pass, Lieutenant Crosby was enabled to get a comparison with their self-registering gauge at that locality.

This gauge is referred to a plane of reference depending upon continuous observations for six years.

Lieutenant Crosby observes that the work of the season showed a continuation to the eastward as far as Calcasieu River of the outlying shoal developed during the previous year by Lieut. G. C. Hannus, U. S. N., Assistant. The portion developed in 1885 was found to be irregular in form and lumpy, with a least depth of nineteen feet. The bottom is of sand and shells and in perfectly smooth water may be seen distinctly to a depth of six fathoms.

Outside of this shoal, and about thirty miles off shore, was found a ridge formed of broken shells, the eastern end bearing south one-quarter west from Calcasieu light, and having on it a least depth of five fathoms and three and a half feet bearing south (magnetic) from Calcasieu light. Outside, inside, and between these shoals the bottom is of blue mud, mixed in some places with broken shells. On both sides of the shoals the water deepens rapidly.

Each of the rivers or passes, Sabine, Calcasieu, and Mermentau, emptying into the Gulf on this portion of the coast, has an enlargement or lake at a few miles inland, forming a tidal reservoir, and causing very strong tidal currents between the lakes and the Gulf. Each is obstructed by a bar at its mouth. Over the bars at Sabine and Calcasieu but six feet of water can be carried at low tide, and over the Mermentau bar but four feet.

With regard to the current in this part of the Gulf, Lieutenant Crosby remarks that they are governed by the direction of the wind, and that in calm weather there is a set of from one-half to one knot to the westward.

Lieutenant Crosby had the aid of the following named officers: Ensigns T. M. Brumby, A. L. Hall, J. H. Hetherington, and J. S. Watters, U. S. N.

The statistics of the season, which closed June 5, are as follows:

Miles run in sounding .....	1,405
Angles measured .....	5,100
Number of soundings .....	53,052

## SECTION IX.

### TEXAS AND INDIAN TERRITORY, INCLUDING GULF COAST, BAYS, AND RIVERS.

(SKETCHES Nos. 1, 9, 17, and 18.)

*Determination of the longitude of Brownsville, Tex.*—Reference has been made, under the heading of the previous section, to the occupation of the longitude station at Galveston, Tex., by Assistant Edwin Smith as an initial point for the determination of the longitude of certain primary and secondary points in Texas and Arkansas. The plan of work included the determination of Brownsville, Tex., in latitude and longitude. The station at Brownsville was established by Sub-assistant E. D. Preston, and after many delays, owing to unfavorable weather, difficulties of transportation, and accidents to the lines, an exchange of telegraphic signals for longitude was obtained with Mr. Smith at Galveston, May 6. Stormy weather prevailed for nearly a week after this date; during this interval Assistant Sinclair took Assistant Smith's place at Galveston, and additional exchanges were obtained on the nights of May 12, 13, and 14. The latitude of the Brownsville station was determined, and the position of the transit connected with that of the geodetic station which had been recently established by Assistant Halter in the garrison, near the artillery barracks. A meridian line was laid out at the request of the county surveyor.

An account of the work subsequently executed by Mr. Preston while connected with the longitude party is given under the heading of Section VIII, and a further notice of the operations of this party under the heading of Section XV.

*Triangulation and wire measurement between Point Isabel and Brownsville, Tex.*—The connection of a station in the town of Brownsville, Tex., with the triangulation of the Gulf coast was accomplished in the winter and spring of 1885, by Assistant R. E. Halter. Starting from a point near the mouth of the Rio Grande in January, the triangulation was carried up the river a distance of about ten and a half miles, and thence by a wire measurement combined with measurements of angles at fixed points along the line to Brownsville. Field operations were closed April 15, and

under instructions Mr. Halter sent his instruments and camp equipage to New Orleans for storage and reported at the office in Washington.

The statistics are:

Number of stations occupied .....	12
Number of observations.....	1,070
Length in meters of wire measurement .....	18,976

## SECTION X.

### CALIFORNIA, INCLUDING THE COAST, BAYS, HARBORS, AND RIVERS.

(SKETCHES Nos. 2, 9, 10, 11, 16, 17, and 18.)

*Survey of the coast line connecting the work at San Juan Capistrano with that at Newport Bay, California.*—At the beginning of the fiscal year, Assistant A. F. Rodgers had organized his party, in pursuance of instructions, and was engaged in the work of completing the coast-line survey between San Juan Capistrano and Newport Bay, California. Between July 1 and 15 three of the points of the triangulation of 1875 in the vicinity of Newport Bay were recovered; the necessary signals, twenty-eight in number, to continue the coast triangulation to San Juan Capistrano were then erected, and a general reconnaissance was made from that vicinity southward to San Diego Bay.

On July 15 Mr. Rodgers proceeded to San Francisco to purchase an outfit of tents for his party, and to attend to certain office work that was needed. He made and forwarded to the office a tracing of the shore-line survey from San Juan Capistrano southward to San Mateo Point. On August 7 he left San Francisco for the south coast, and moved his party to Laguna Cañon. Sub-assistant Isaac Winston reported for duty in the party August 14. During August and September observations of horizontal angles were prosecuted, and early in October the field computations were sufficiently advanced to furnish data for the projection of a topographical sheet to cover the survey of the shore line included in the triangulation. This topographic survey was prosecuted till November 1, when the exhaustion of the appropriation compelled the suspension of field operations.

Mr. Rodgers acknowledges the courtesy of Hon. Richard Egan, of San Juan Capistrano, in giving the use of an adobe building, comparatively fire proof, for the storage of the instruments at the close of the season, free of charge. He commends also the efficient and ever-ready service of Mr. Winston, who remained with the party until its arrival in San Francisco, when he was detached and ordered to duty at Los Angeles.

During the remainder of the fiscal year Assistant Rodgers was engaged on office work at San Francisco. On December 26, at the request of Assistant Davidson, who had been ordered to Washington, he took charge of the suboffice at San Francisco, and continued on that duty till Mr. Davidson's return in April. At the close of the fiscal year he had made all arrangements to take the field in accordance with instructions, and left San Francisco, by the south coast steamer, June 30.

The statistics of the season of 1884 are:

Number of stations occupied .....	35
Number of stations and objects observed on .....	45
Number of horizontal directions determined .....	834
Number of horizontal angles measured.....	4,990
Number of pointings made.....	10,814
Number of geographical positions determined .....	34

*Series of observations continued at the magnetic self-registering record station at Los Angeles, Cal.*—Since October, 1882, an almost unbroken series of absolute and differential magnetic observations has been maintained at the Magnetic Observatory at Los Angeles, Cal. At the beginning of the fiscal year 1884-'85, Assistant Marcus Baker, who had begun this series of observations, was still in charge of them, but with instructions for his relief from that duty and recall to Washington. Mr. Carlisle Terry, Aid in the Survey, had been directed to report to Mr. Baker in order

to learn the methods of observation and qualify himself to take charge of the observatory. On the 1st of August, 1884, Mr. Baker proceeded to Washington, by way of Toronto, Canada, under instructions for special duty and for conference with the Superintendent respecting magnetic work. Reference is made under the headings of Section II and special operations, to duty assigned to Mr. Baker on the Atlantic coast.

Mr. Terry has submitted a full report of his work during the eleven months ending with June, 1885. The photographic records of the elements of the relative magnetic declination, dip, and intensity, with the Adie magnetographs were made as nearly continuous as possible. During three days near the middle of each month observations were made to determine the absolute declination, dip, and horizontal intensity, and from these absolute vertical force and total intensity were deduced.

Time was determined once a month by observations of the sun.

On September 7 and November 30 the vertical force magnet was rebalanced, and on the same dates, and also on December 4, its scale values were redetermined. The unifilar, bifilar, and vertical force scales were read each day before and after changing the photographic papers; readings were taken also of the maximum and minimum thermometers each day at 8 a. m. and 5 p. m. Hourly readings of the unifilar, bifilar, and vertical force traces were made, and hourly, daily, and monthly means for each month deduced.

At the time Mr. Terry took charge of the observatory much difficulty had been experienced in obtaining photographic traces of sufficient distinctness, but by using the greatest care he was able to procure a record. In November, 1884, by making some slight changes in the sensitizing process, and by the use of new trays, some improvement was secured, and on the 1st of June, 1885, gelatino-bromide paper was substituted for the bromo-iodide of silver paper previously in use. The gelatino-bromide paper, Mr. Terry reports as having the advantage of reducing the amount of labor needed to procure a record, and as far more uniform and continuous in its results.

Mr. Terry had the assistance of Subassistant Isaac Winston from November 15, 1884, to April 30, 1885, and of Mr. A. L. DuPuy from May 10 to the close of the fiscal year.

A summary of the year's statistics is as follows:

Number of absolute measures . . . . .	5,280
Number of relative measures . . . . .	6,012
Number of readings of photographic traces . . . . .	42,610

The records, computations, and abstracts of results to the close of the fiscal year have been transmitted to the office.

*Continuation of the primary triangulation of the coast of California north of Point Concepcion.*—Field operations in continuation of the primary triangulation of the California coast north of Point Concepcion were resumed by Assistant James S. Lawson in November, 1884, the condition of the atmosphere not being favorable for work at an earlier period in the fiscal year. The station selected for occupation was Rocky Butte, a primary point of three thousand four hundred feet elevation, about six miles from the coast.

Knowing the violence of the winter gales, Mr. Lawson deemed it advisable to erect a temporary wooden observatory for the shelter of the instruments, instead of using tents, and the advantage of so doing was proved by experience, one of the heavy rain storms accompanied by high winds having lasted ten days.

The work at Rocky Butte consisted of horizontal and vertical measures, and observations for time and latitude. For horizontal direction observations were made upon thirteen objects, six of which were heliotropes at primary stations, one the light-house at Piedras Blancas, one a station at Hollister Peak, and five poles, four of which belonged to the tertiary coast triangulation.

The theodolite was used in twenty-three positions; and at all of the pointings on the principal stations, readings of the ocular micrometer were taken. On all prominent mountain peaks and objects within the horizon of the station pointings were made. For elevation, measurements of double zenith distances were made on six main stations and on ten other objects.

For time, observations were made on six nights, and for the latitude of the station twenty-nine pairs of stars were observed on seven nights. The instruments used in the several classes

of observations were the twelve-inch theodolite No. 131, the eight-inch vertical circle No. 57, and the meridian instrument No. 16.

Work at Rocky Butte was closed January 31, 1885, and the camp was at once moved to the vicinity of Castle Mountain, with the intention of occupying that station, but it was found that the appropriation was too far exhausted to permit any other course than to disband the party and store the camp equipage till next season.

Mr. Lawson reports the following statistics of the work :

Number of observations for horizontal direction .....	1,002
Number of observations for vertical measures .....	762
Number of observations for latitude .....	212
Number of observations for time .....	58

On returning to San Francisco a determination of the value of the micrometer of the meridian instrument was made at the astronomical station in Lafayette Park, the sets obtained at Rocky Butte having been much broken by clouds.

In all of the operations of the party Mr. Lawson had the assistance of Mr. P. A. Welker, Aid, and speaks highly of the value of his services. During the remainder of the fiscal year Mr. Lawson was engaged in office work, and towards its close received instructions to prepare for taking the field. The records and computations of his observations at Rocky Butte were completed and sent to the office.

*Survey of the coast of California continued from Moro Bay westward.*—At the beginning of the fiscal year Assistant Stehman Forney had received instructions to continue the tertiary triangulation of the coast of California and the shore-line topography from Moro Bay westward. At the close of the season, which was a short one, on account of the smallness of the appropriation, Mr. Forney had carried his survey to the line Irving-Estrada, within three miles of the town of Cambria, San Luis Obispo County. By the end of October the shore line and topography of two full plane-table sheets were completed, and the shore line on a third sheet for a distance of six miles. Every opportunity was taken advantage of to connect the tertiary points with the primary triangulation.

Statistics of the season are :

Number of stations occupied .....	2
Number of signals observed upon .....	11
Number of angles measured .....	480
Miles of shore line surveyed ..	8
Miles of creeks .....	17
Miles of roads, telegraph, and fences .....	78
Area surveyed in square miles .....	18

*Hydrographic survey of the California coast in the vicinity of San Simeon.*—As mentioned in the last annual report, the hydrographic party under charge of Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer McArthur, was near San Simeon, Cal., at the beginning of the fiscal year, engaged in hydrographic work off that part of the coast. The limits of Lieutenant Taussig's survey, which began June 3 and ended July 16, 1884, were from Pecho Point, near San Luis Obispo Bay, to a point beyond Cayucos in Estero Bay.

Some extracts from Lieutenant Taussig's report, relating to the hydrographic characteristics of the coast will be of interest :

"The harbor of San Simeon, in the northeastern part of San Simeon Bay is a good summer anchorage. Vessels approaching from the southward can work up the bay without danger as long as they keep clear of the kelp, which generally lines the shores within the three-fathom line. Off the peninsula, which forms the western side of the harbor of San Simeon, is a reef lined with kelp, on which the sea generally breaks. This reef extends in thick kelp for a distance of three-sixteenths of a mile southeast of the point into six fathoms of water, and one-eighth of a mile further to the southeast there are three small pieces of detached kelp in seven and a half fathoms of water. In order to avoid this reef, my usual course in entering San Simeon Harbor in a fog

was to feel my way to the kelp on the eastern shore and then head about northwest until the anchorage was reached.

"The best anchorage for light-draught vessels is about one-eighth of a mile east of Whaler's or Clark's wharf, in three fathoms of water (at *low* low water) where there is a good lee from the north-west winds. In the winter months, the southwest swell makes this anchorage, like most of the ports on the coast, an unsafe one. If, however, obliged to ride out a gale, the same anchorage is to be preferred, as the reef and peninsula serve to break the sea somewhat.

"The shores along the coast, from the harbor of San Simeon to the northwest are low bluffs, with occasional small stretches of sand beach. The country rises into mountains about two miles from the coast. These mountains dip towards the sea, and reach the coast at the end of our work northwest of Arroyo San Juan Carpofero.

"Off the shore the coast is generally lined with kelp, and the soundings are irregular; the general character of the bottom is rocky; gray sand is found off the Castro House, and formerly schooners anchored there and lighted off their freight. Since the construction of the wharf in the harbor of San Simeon this has not been done. Patches of kelp are found in as much as thirteen fathoms of water one-half mile south by west of Castro station. One and one-eighth miles southwest one quarter south of Castro House is a rock with three and one-fourth fathoms in kelp, and irregular soundings from six to nine fathoms around it. This is the outer danger of the coast between the peninsula of San Simeon and the rocks called Piedras Blancas. Vessels bound from San Simeon northward should keep three-fourths of a mile off shore in order to keep in not less than ten fathoms of water, while patches of kelp may be found a mile off shore.

"Vessels may approach the rocks called Piedras Blancas with impunity, taking care not to approach too close on the western and northwestern sides, as the bottom is foul and rocky."

Lieutenant Taussig gives in detail other statements respecting dangers to be avoided in approaching the coast, and his report will furnish valuable material for the forthcoming new edition of the Coast Pilot of California and Oregon.

With regard to the examination of the bar of San Francisco, to which some days were devoted in June, and one day, the 18th, in July, Lieutenant Taussig remarks that while all the time occupied there was well spent, he does not think the examination complete enough to state officially that the bar has not changed. It was his impression, however, that no material changes have taken place, and that a survey will probably show slightly deeper water in the southern channel than is given by the chart, and a possible extension of the southern end of the Four-Fathom Bank. The specimens of bottom show no signs of silt, and the living animals on the crest of the bar prove that the mining débris, and the silt of the streams emptying into the bay have not yet effected a deposit.

Lieutenant Taussig expresses his obligations to Assistant Forney for valuable information and services in connection with the work in the neighborhood of Cayucos, and to Assistant Davidson for information relating to the San Francisco Bar, and other data of value. The efficient aid afforded by the officers attached to the party is acknowledged: Lieut. F. H. Lefavor, and Ensigns W. L. Burdick, P. B. Bibb, and J. L. Purcell, U. S. N.

The statistics of the hydrography are:

Miles run in sounding .....	1,069
Angles measured ... ..	5,221
Number of soundings.....	30,057

On the 1st of October Lieutenant Taussig was instructed to resume the hydrographic survey of the northern coast of California. An account of this work, and of that subsequently executed by his party under instructions dated in February, 1885, will be given under a later heading in this section.

*Occupation of stations in continuation of the primary triangulation of the coast of California.*—In July and during part of August, 1884, Assistant George Davidson was in Washington, having been called there for conference with the Superintendent, but he continued to direct the main triangulation and astronomical work on the coast of California, the Saucelito and Alaska tidal parties, the Coast Pilot work, and other operations, reference to which will be made here. Upon



returning to the Pacific coast towards the close of August, Mr. Davidson was instructed to proceed by way of the Atlantic and Pacific Railroad, following the thirty-fifth parallel, in order to study the features of that region with reference to its availability for geodetic work, for magnetic observations, &c. In December, 1884, he was again ordered to Washington for conference with the Superintendent, and in March, 1885, returned to San Francisco.

In the month of April following Mr. Davidson was placed, by special instructions, in charge of the operations of the survey on the Pacific coast, the hydrographic work and the magnetic work at Los Angeles excepted. He was to submit to the Superintendent a systematic programme of work for Sections X, XI, and XII, indicating assignments that would be advisable, giving detailed instructions to officers in charge of parties, and supervising generally their operations. He was to take charge of the suboffice at San Francisco, and regulate all details connected with it.

During his absence in the summer of 1884 the work of copying and computing the triangulation, astronomical, and magnetic observations of the previous season was completed, and as soon as a prospect of fair weather for field work appeared, Mr. Davidson's party occupied Mount Diablo, a station of the main chain in Contra Costa County. At Mount Diablo horizontal and vertical angles and magnetic declination were observed. The instruments used were the twenty-inch theodolite No. 115, vertical circle No. 80, and magnetometer No. 3. Extremely boisterous weather prevailed and long storms retarded the work.

Mr. Davidson remarks that at this station the experience of the party in the previous triangulation work was verified with regard to the better showing of the heliotropes in the winter months as compared with the summer, but the drawbacks in rainy seasons are very great when the party has to move to different stations or is encamped at an exposed station.

By the end of December all of the observations required at Mount Diablo had been obtained, and preparations were begun for moving camp to Toro Mountain, a station of the primary coast triangulation, about ninety-five miles in a southwesterly direction from Diablo. Observations at Toro were begun January 20. The same character of work was done as at Diablo, with the addition of observations for time, latitude, and azimuth. Field work at Toro was closed, and the party discharged February 13.

Assistant Davidson expresses his hearty commendation of the prompt, cheerful, and energetic execution of all duty intrusted to them by Subassistant R. A. Marr, and Aid Fremont Morse, attached to his party. Mr. Marr made the observations for horizontal directions and azimuth; Mr. Morse those for vertical angles, time, latitude, and the magnetic elements. At Mount Toro Mr. C. B. Hill, acting aid, assisted in the observations and in recording.

At Diablo observations were taken on the north dome of the Lick Observatory, at Mount Hamilton, to check the observations of the previous seasons.

The statistics of work at Diablo and Toro are as follows:

At Diablo:

Series of observations for horizontal direction .....	82
Number of observations of horizontal direction .....	344
Number of ocular micrometer pointings .....	1,350
Number of observations of vertical angles (eight stations observed) .....	178

At Toro:

Series of observations for horizontal direction .....	89
Number of observations of horizontal direction .....	327
Number of ocular micrometer pointings .....	1,300
Number of observations of vertical angles (twelve stations observed) .....	158

In April, 1885, Mr. Marr was relieved from duty in Mr. Davidson's party and ordered to the steamer Patterson.

Towards the close of the fiscal year, there being a small amount of the allotment available, Mr. Morse was directed to occupy the two triangulation stations, Rocky Mound and Red Hill, overlooking the bay of San Francisco, the object being to make the most direct connection with the triangulation depending on the Yolo base. For this work the ten-inch Gambey repeating theodolite was used, and the vertical angles were connected with Red Hill station, to which

Assistant Cutts had formerly run a line of levels from San Francisco Bay. Mr. Morse has furnished the following statistics of work at the two stations:

Number of horizontal angles measured .....	8
Number of observations for horizontal angles .....	744
Number of vertical angles measured .....	6
Number of observations of vertical angles .....	153

A determination of the geographical position of the Yaquina Light House, on the coast of Oregon, having become desirable, Mr. Morse was instructed to proceed thither, and fix the latitude and longitude of a station which could be connected with the old tertiary triangulation and with the light house. He succeeded in obtaining thirty-one observations on twenty-four pairs of stars, on three nights, with the Davidson meridian instrument No. 1, and also observed one lunar transit for longitude. The correction to the latitude of the Light House was 55'', nearly one mile.

*Coast Pilot work.*—With regard to the Coast Pilot work, involving the preparation for publication of a new edition of the Coast Pilot of California, Oregon, and Washington Territory, Mr. Davidson reports that F. Westdahl, draughtsman, in addition to other duties, finished the series of views which he had taken at sea during the previous season. These include many of the headlands between San Diego and San Francisco. In December Mr. Davidson himself made a trip to fill in views not obtained before. In May and June Mr. Westdahl made a trip to the northward as far as Puget Sound to obtain views, with fair success, despite unfavorable weather.

On account of the large accumulation of material from surveys made since the last edition of the work was published, the labor on details has been very great.

*Magnetic observations.*—As the time of the maximum of easterly magnetic declination is rapidly approaching the part of the coast in the vicinity of San Francisco, Mr. Davidson kept up observations for declination and intensity at the old astronomical station at the Presidio of San Francisco. Observations for declination were made by himself and by Messrs. Marr and Morse on seven days, and referred to the station, Mount Tamalpais east; also observations for total intensity, &c.

*Longitude of a station of the Hawaiian Government survey.*—At the request of Prof. W. D. Alexander, chief of the Hawaiian Government survey, who was anxious to connect one of his stations with a station of the Coast and Geodetic Survey for difference of longitude, Mr. Davidson undertook to obtain time, and compare with Professor Alexander's chronometers sent to San Francisco by each steamer. But the whole of the work of observing, comparing, and reducing was done by Mr. Charles B. Hill, mostly outside of official hours.

*San Francisco suboffice.*—In the suboffice at San Francisco, under the immediate charge of Assistant Davidson, Mr. Ferdinand Westdahl served faithfully throughout the year as draughtsman, and, as already mentioned, was part of the time on detached duty. Mr. C. B. Hill served acceptably as clerk, and when required took part in field work. Vicente Denis, as janitor, had care of the camp outfit, &c., of the field parties, and did his work well, without regard to hours.

*Field catalogue of time and circumpolar stars.*—Outside of his official duties, Mr. Davidson continued work upon his field catalogue of time and circumpolar stars (Appendix No. 18, Report for 1883), so as to enlarge it for a future edition.

*Rocks in Mission Bay.*—Conflicting reports having arisen in regard to the position of certain rocks in the channel off Point of Rocks, Mission Bay, San Francisco, Mr. Davidson caused a thorough examination to be made of the locality, and established the fact of the existence of two separate rocks, a north rock and a south rock. Upon Mr. Davidson's recommendation, a buoy was placed on the south rock also, it being abreast of two of the largest and busiest wharves of the whole city front. Upon the chart of San Francisco entrance, edition of 1884, both rocks are shown, the north one as Mission Bay Rock, the south one as Sonoma Rock.

*The bar of San Francisco.*—An elaborate report has been submitted by Mr. Davidson upon the bar of San Francisco, with special reference to changes reported to have taken place in it. Tracings accompany the report, showing the lines of the six and ten fathom curves according to the surveys of 1855 and 1873; also a tracing of several cross-sections of the bar. Mr. Davidson's

conclusions are decidedly adverse to the supposition that any changes of moment have occurred. Some extracts from his transmitting letter will be of interest.

"It has been asserted recently that the south channel had been abandoned on account of the shoaling. This statement is directly contrary to the fact. On the afternoon of the day the statement was published, I saw a deeply laden British bark crossing by the western edge of the south channel when the bar was very rough, almost breaking all round."

"It has been asserted that great deposits have taken place inside the bar within the ten-fathom line; the statement is contrary to the fact. It is relied upon as necessarily proving deposition of material, that the muddy waters of the Sacramento River deposit their material on the bar, &c. In a certain degree, this action of deposition is inevitable, but it will first take place in more favorable situations than on the bar. I have shown, many years since, that the deeply discolored waters of the Sacramento and other rivers were carried north of Point Reyes."

"I wish to repeat former recommendations which I have made on the subject: that every ten years a minute resurvey of the bar and immediate approaches should be made to *study the law of change, if there be any*. With this survey there should be such an examination of the material of the bar as would establish the source of the supply. I believe that it is mainly due the coast eddy current from the southern shore line."

*Self-registering tide-gauge record kept up at Saucelito, San Francisco Bay.*—Assistant Davidson reports that the work at this station, which is carried on under his supervision by Mr. E. Gray, has been of uniformly good character and without break in the record during the year. The tabulations and the original sheets have been regularly forwarded to the office. Observations for time and comparisons of chronometers were made when required by Mr. C. B. Hill. During the year the pier was in some danger, because the *teredo* had destroyed nearly all the bracing of the piles and the protection against heavy swells. The repairs necessary were made.

Reference to the work of the Alaska tidal party, also under Mr. Davidson's general supervision, will be found under the heading of Section XII.

*Hydrographic surveys on the California coast in Humboldt Bay and between Brushy Point and White Rock.*—In pursuance of instructions for the execution of hydrographic work on the north coast of California, Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *McArthur*, left San Francisco, October 18, 1884, bound for Humboldt Bay. An examination of this bay and its approaches was made a secondary object, to be accomplished when work outside off Cape Mendocino was found impracticable, but every attempt made by Lieutenant Taussig to do off-shore work was frustrated by bad weather, so that ultimately he was compelled to confine his survey to the waters of Humboldt Bay. The months of November and December, which are generally favorable, proved particularly stormy in 1884.

The survey of Humboldt Bar was made in the large life boat of the life saving station. The bar, especially during the winter months, is generally rough. Vessels are detained not unfrequently for many days in going out, and sometimes in coming in.

With regard to the channel, Lieutenant Taussig found that since last October it had been to the southward of the middle ground, and for eighteen months before that time to the northward, changing so frequently, however, that no chart can be of any aid to a stranger crossing the bar. The positions of the buoys on the bar and in the channels are often changed by the pilot tugs, but not as often as the channels change, and the buoys must not be accepted, therefore, as guides by strangers.

To obtain a plane of reference for the soundings, a tide-gauge was established at Field's Landing.

Lieutenant Taussig expresses his special indebtedness to Ensign J. N. Jordan, U. S. N., for unflinching zeal and attention to duty. Ensigns W. L. Burdick and F. A. McNutt, U. S. N., were also attached to the party, and rendered acceptable service.

Statistics of work in Humboldt Bay are:

Miles run in sounding .....	166
Angles measured .....	936
Number of soundings .....	7, 020

Early in December the *McArthur* returned to San Francisco, and was taken to the Mare Island navy-yard for repairs. On the 8th of April, 1885, all preparations having been completed for work on the north coast, Lieutenant Taussig and his party left San Francisco for Brushy Point, and anchored off that point the next day. He was provided with two hydrographic sheets, each on a scale of 1-20000; the first with limits from Brushy Point to Ussal Rock, the second from Ussal Rock to White Rock.

Lieutenant Taussig observes that the general hydrographic features of this part of the coast are in the main similar to those of the coast immediately to the southward. The land is bolder, the coast range comes close to the ocean, and at times so close as to rise almost vertically from the sea. Here and there a flat has induced a settler to start a cattle ranch.

The anchorages along this section are not to be recommended. None of them have any lee. A few projecting rocks, with a more or less fancied freedom from undertow, or affording some slight protection from the full strength of the wind have induced some persons to build chutes from Brushy Point, Kibessilah, Westport, Cottaneva, and Bear Harbor, and when the roads are passable, and the southeast gales not too frequent, these chutes do a lively business in shipping bark and redwood lumber.

The projecting headlands at Cottaneva, Big White Rock, Bear Harbor, Shelter Cove, and Point Gorda break the force of the sea in the strong northwesterners that prevail during the summer months. The small coasting steamers take advantage of this in running up the coast. Strangers, however, unfamiliar with the coast and the soundings near it, should not approach it, between Brushy Point and Ussal Rock, nearer than half a mile without great caution. The dangers are as a rule in sight, but the uneven and rocky character of the bottom and the peculiar form of some of the sunken rocks makes it very probable that a number are as yet uncharted.

With the above general statement, Lieutenant Taussig presents in his report full details respecting the several localities included in his survey. To obtain planes of reference for his soundings, he established a tide-gauge at one of the rocks near the south chute at Westport. At this point tides were observed from April 12 to June 12, inclusive. Tidal observations were made also at Little River for two days to connect with the tide-level at Westport, and also to reduce the supplementary soundings taken in Little River to define the line of reef, and to locate a pinnacle rock (heretofore unknown) in the northwestern part of the harbor.

The following named officers served on board the *McArthur* during this work: Ensign J. N. Jordan, U. S. N., till his detachment May 31, and Ensigns W. L. Burdick, J. A. Bell, and F. A. McNutt, U. S. N.

Statistics of the season are:

Miles run in sounding .....	1, 417
Angles measured .....	3, 920
Number of soundings .....	23, 979
Number of specimens of bottom preserved .....	40

About the middle of June the *McArthur* returned to San Francisco.

## SECTION XI.

### OREGON AND WASHINGTON TERRITORY, INCLUDING COAST, INTERIOR BAYS, PORTS, AND RIVERS. (SKETCHES Nos. 2, 11, 12, 17, and 18.)

*Triangulation and topography of the Umpquah River, Oregon.*—In continuation of the survey of the Umpquah River and of the adjacent coast, Assistant Louis A. Sentgeller took the field, under instructions, at as early a period in the spring of 1885 as the allotment for his work would permit. Having organized his party towards the end of April, he established his camp on the Umpquah early in May, and proceeded at once to recover and readjust the triangulation stations of preceding seasons, re-establishing two stations which had been destroyed. The season proving to be favorable, the triangulation north of the Umpquah was resumed and developed so far as necessary to insure a permanent base or bases for future requirements in carrying the work northward.

The selection of stations was attended with difficulty, owing to the formation of the country;

abrupt and high sand hills, timbered close to the coast line. Observations of horizontal angles were begun May 12 and continued till June 14, at which date complete connections had been established to the northward, and sufficient results obtained to furnish the points necessary for the topography and hydrography of the Umpquah River.

On June 16 the entire party was transferred to the beach between Umpquah River and Coos Bay, with a view of effecting a junction with the triangulation which had been executed in that locality by Assistant James S. Lawson. A temporary camp having been established at Ten-Mile Creek, about half way between the two entrances, a reconnaissance was developed from the creek, both northward and southward, while at the same time observations of horizontal angles were made to follow up the reconnaissance as it advanced from the Umpquah.

Towards the end of June Mr. Sengeteller proceeded with his party to Empire City, Coos Bay, and in that vicinity recovered two stations of the former triangulation, the line joining which served as a base for the desired connection. Until June 30 the reconnaissance and erection of stations southward from the recovered line "Pony-Simpson" was continued, a complete junction being effected, leaving two stations to be erected, and, if possible, one of former work to be recovered.

South of Umpquah River and toward Coos Bay the character of country was found to be similar to that already alluded to north of Umpquah entrance, namely, a low sand beach, backed for about half a mile by bare sand dunes of all imaginable shapes, gradually increasing in height as they recede from the coast until about one mile from it, when defined ridges and hills appear, the latter reaching an average elevation of about two hundred feet. These are backed by densely timbered ridges and hills of greater elevation, interspersed with many lakes and ravines and practically impenetrable. But occasional glimpses of the mountains in the interior can be obtained. At the mouth of Ten-Mile Creek but a very small part of the Umpquah hills can be seen, and this from points less than half a mile apart.

Mr. C. W. Fitzgerald served acceptably as recorder of the party.

Statistics of the season to the close of the fiscal year are as follows:

Number of stations determined.....	15
Number of stations occupied.....	19
Number of angles measured.....	201
Number of observations made.....	4, 072

As this survey is in active progress at the date at which this report closes, further mention of it will be made in the next annual report.

*Continuation of the topographical survey of the Columbia and Willamette Rivers. Hydrography of the Willamette River.*—Mention was made in the last annual report of the progress made by Assistant Cleveland Rockwell, at the end of June, 1884, in the topographical survey of the Columbia and Willamette Rivers. As there stated, the steady rise of the waters in these rivers, owing to the annual freshet, compelled Mr. Rockwell to move up the Willamette in his vessel, the Kincheloe, till opposite Saint John, in order to find work on the highlands forming part of the shores of that river. During the highest water he prosecuted the survey around the cities of Portland, East Portland, and Albina. Later in the season he went back again down the Columbia as far as Willow Bar. The representation of the shores of the river was limited to about a mile back from the water's edge on either side, Mr. Rockwell deeming this a sufficient border of topography to meet the needs of the work, the funds for which were limited. In the cities of Portland, East Portland, and Albina a sufficient number of the principal streets were determined to enable a plot of the city surveyor's map to be reduced to the 1-10000 scale of the topographic sheet. On the Portland or west side of the Willamette the survey was continued to include the summits of the first range of hills back of the city.

The season's work is included in two topographic sheets, one on a scale of 1-20000, which joins the topographical work previously done by Mr. Rockwell from Willow Bar up the Columbia to a point a mile above the mouth of the Willamette, and up that river to the head of Swan Island, and the other, on a scale of 1-10000, embracing the city of Portland, extends from the head of Swan Island to the south limit of that city.

Field operations were closed October 10, and the Kincheloe laid up at Albina in care of a ship-keeper.

Following are the statistics of the survey :

Miles of shore line of rivers surveyed .....	62
Miles of shore line of ponds, creeks, and sloughs .....	128
Miles of railroad and all other roads .....	134
Area of survey in square miles ..	43

Towards the end of the fiscal year, Mr. Rockwell was instructed to organize his party for the hydrographic survey of the Columbia River, and at the date at which this report closes was actively engaged in the prosecution of that work.

*Completion of the topography of Hood's Canal, Washington Territory. Reconnaissance of the Olympic Mountains.*—At the beginning of the fiscal year Assistant J. J. Gilbert, in pursuance of instructions, was in camp at Union City, near the head of Hood's Canal, engaged upon the topography of that inlet. The weather in the three months following was very favorable for field work, and the last topographical sheet of Hood's Canal was completed early in October. A trail connecting the head of the canal with Case's Inlet was run during the season in order to check the work.

In September a trip for reconnaissance was made to the Olympic Mountains, in order to learn something of their character, and to take some observations for the position of some of their principal peaks. Mr. Gilbert has submitted an elaborate report of this trip, accompanied with sketches of the horizon and tables of barometric readings and approximate heights. Mount Ellinor, the highest peak, was found to have an altitude of sixty-two hundred and seventy-two feet.

The statistics of the topographical survey are as follows :

Miles of shore line surveyed ..	67
Miles of roads surveyed .....	61
Area surveyed in square miles .....	40

During the winter Assistant Gilbert was engaged in office work, and before the close of the fiscal year had transmitted to Washington his original sheets, with tracings of the same.

*Hydrographic surveys in Hood's Canal, Washington Territory.*—As mentioned in the last annual report, a hydrographic survey was in progress at the beginning of the present fiscal year in the vicinity of Seabeck, on Hood's Canal, Washington Territory, under the direction of Ensign J. N. Jordan, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Earnest. On July 19, 1884, in pursuance of instructions, Lieut. C. F. Forse, U. S. N., Assistant Coast and Geodetic Survey, proceeded to Seabeck and took charge of the party, relieving Ensign Jordan in command.

Upon Lieutenant Forse's arrival he found that Ensign Jordan had just finished the first hydrographic sheet, extending from Hazel Point to station Quatsap, including Dabop and Quilcine Bays; scale 1-20000. Work was at once begun on a second sheet of the same scale, extending from station Quatsap to station Cabin, and covering the upper part of Hood's Canal. Within the area covered by these sheets the water is very deep, increasing to over one hundred fathoms in places, and the shores as a rule very bold. The curve of fifty fathoms depth averages not more than half a mile from shore, and in many places is much nearer.

Lieutenant Forse states that no obstacles to navigation exist except a small ledge of rocks on the west side of Dabop Bay, which extends out at right angles with the shore line about fifteen hundred metres, (forty-nine hundred and twenty-one feet). At the mouths of the Dociwalaps, Duckabush, and Hamahama Rivers the flats extend out from the shore line in a semi-circle for over half a mile, and then the water deepens suddenly to over twenty fathoms. Quilcine, Seabeck, and Pleasant Harbor afford excellent anchorage.

A plane of reference (the mean of the lowest low waters) was determined by observing the tides day and night for a lunar month at a tide-gauge established in Seabeck Harbor, and referred to a bench-mark made by drilling a half-inch hole in the top of the rock used as station Seabeck.

The allotment of funds becoming nearly exhausted by the end of the first month of the fiscal

year, Lieutenant Forse, in accordance with instructions, made arrangements for a reduced party, but was able, by urgent effort, to finish the hydrography to the limits of the Upper Hood's Canal sheet. This was accomplished by August 24. To that date the statistics are:

Miles run in sounding .....	424
Angles measured .....	2,675
Number of soundings .....	5,958

During the winter the Earnest and the steam-launch Tarrynot were laid up near Olympia, W. T. On June 6, 1885, in pursuance of instructions to proceed with hydrographic work in Hood's Canal and the waters east of Bainbridge Island, Lieutenant Forse made preparations for getting the schooner and steam-launch in readiness, and at the end of the fiscal year was about to begin the hydrography.

*Triangulation and topography of Possession Strait and Sound, Washington Territory.*—Reference was made in my last annual report to the beginning of the survey of Possession Strait and Sound, Washington Territory, by Assistant J. F. Pratt. He had organized his party, in pursuance of instructions for this survey, on board of the schooner Yukon, and by the 1st of July, 1884, had carried the triangulation from two of the main points in Admiralty Inlet to the line Muckilteo-Turkey, at the entrance of Possession Sound.

By July 18 the triangulation was sufficiently advanced to take up the topography, and both were pushed until the delta of the Snohomish River was reached, when the triangulation was suspended and all the energies of the party devoted to the topography. Instructions to close work, on account of the insufficiency of the funds available, were received before the survey of the Snohomish River could be carried to the head of steamboat navigation, at Snohomish City. The stations at which the work was suspended were marked, so that it can readily be resumed. Field operations were closed September 1.

Mr. Pratt observes that there is very little, if any, time in which there are not very strong currents in either one or the other direction in Possession Sound, the average rise and fall of the tide being about ten feet, and there being two high and two low waters daily. During midsummer there are very strong periodical northerly winds, interspersed with one or two southeasterly gales, and either of these produce, when blowing contrary to the tidal currents, tide rips, which are sometimes dangerous to the smaller boats used in the survey.

Statistics of the season are as follows:

Number of stations occupied in the triangulation .....	6
Number of angles measured .....	137
Number of single measures .....	4,830
Number of geographical positions determined .....	24
Number of miles of shore line surveyed .....	13
Number of miles of rivers and creeks .....	61
Number of miles of shoals .....	16
Number of miles of roads and railroads .....	3

Early in September Assistant Pratt was directed to report to Assistant B. A. Colonna for duty in his party, and to transfer to him at the same time the schooner Yukon. Details of the joint labors of these officers in the survey of the Strait of Fuca will be given under the next heading.

Towards the latter part of the fiscal year, upon being relieved from duty in Mr. Colonna's party, the schooner and her outfit were turned over to Mr. Pratt, and he was instructed to resume work in Possession Sound.

*Reconnaissance for the triangulation of the Strait of Fuca.*—At the beginning of the fiscal year Assistant B. A. Colonna was actively engaged, in pursuance of instructions, in a reconnaissance for the triangulation of the Strait of Fuca. As this work would involve the occupation of a number of stations on Vancouver Island, Mr. Colonna, soon after his arrival, had called upon Lieutenant-Governor Cornwall, of the Dominion Government, at Victoria, British Columbia, and obtained,

through the American consul, all necessary authority to land on the shores of British Columbia for the purposes of the survey.

By invitation of Lieut. Commander A. S. Snow, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *Hassler*, Mr. Colonna took up his quarters on board, the party on the *Hassler* being at that time engaged in erecting signals at the east end of the strait. With the advantages of transportation thus afforded, he became acquainted with the country as far west as Esquimalt Harbor. He then left the *Hassler* and took a trip on a tug to study the south shore as far as Nēēah Bay. Some means of transportation it became now absolutely necessary to have at his sole control in order to visit the more inaccessible places on the lower strait. A steamer of some kind would have been exceedingly desirable, but none being available at a reasonable cost, Mr. Colonna hired a fishing-boat, twenty-six feet long, and made arrangements to live on board. From the line Dungeness-Discovery, at the eastern end of the strait, he carried the reconnaissance to the line Slip Point-Sherringham Point, and was preparing to take the next step west, when, on the 9th of August, from the combined effects of overwork and an accident, he found himself paralyzed, and was taken to the hospital at Victoria.

In this emergency the arrival of Assistant Pratt with the schooner *Yukon* was exceedingly opportune; he was followed in a few days by Mr. T. P. Borden, who reported for duty as Aid. Messrs. Pratt and Borden prosecuted the reconnaissance with vigor to the westward in the *Yukon*.

On the 12th of September the vessel got under way for the lower straits, but, owing to calm weather and strong tidal currents, very slow progress was made in getting from point to point. Often, when nearing the shore, the wind would die out, and then there was great danger of shipwreck by being carried on the rocks by the strong and treacherous tidal currents, running, in some instances, as much as five or six miles an hour. On one occasion the *Yukon* was carried within twenty feet of the rocks at Beechey Head before her anchors would hold.

Mr. Pratt observes that during a great portion of the time there is a very heavy swell rolling in the straits, producing a heavy surf on the shores. These being mostly rocky, great skill and judgment are needed in managing a landing in a boat. To insure safety in landing, a steam vessel should be used. In a steamer the shore can be approached within one-third of a mile, and a reserve boat be held in readiness to render assistance to a landing party in case of accident.

During the ebb and flood tides in many parts of the strait there are tide-rips, which often cover large areas. These rips being composed of irregular and contradictory currents and eddies, combined with a heavy chop sea, small craft, and especially open boats, are always in great peril in them and are often lost.

Mr. Pratt's whole experience attested the truth of the statement of Captain Richards, R. N., in the *Vancouver Island Pilot*, who says of Juan de Fuca Strait that "from its geographical position it is liable to all those sudden vicissitudes of weather common to high northern latitudes, and in few parts of the world is the caution and vigilance of the navigator more called into action than in entering it."

There are no harbors west of Port Angelos on the American side, although there are several anchorages suitable during moderate or southerly weather. On the British side there is but one harbor, Port San Juan, west of Esquimalt, and that is exposed to southwest storms. Beecher Bay should not be made in heavy weather, the tidal currents past its entrance being uncertain and often dangerous.

The reconnaissance, conducted by Assistants Colonna and Pratt with the aid of Mr. Borden, was completed by the middle of October, a scheme of triangulation having been developed from a proposed base on Whidbey Island to Cape Flattery light, on Tatoosh Island, on the American side, and to Bonilla Point, on Vancouver Island, British Columbia. The *Yukon* was laid up at Victoria, British Columbia, October 31. At this time Mr. Colonna was still in the hospital, but as soon as he had sufficiently recovered to bear removal he took up his quarters on board the *Yukon*, and by the end of the year was able to attend to office work.

A comprehensive report has been submitted by himself and Mr. Pratt, exhibiting the condition of the work at date (January 27, 1885), suggesting the most practicable methods for its execution, stating the modes of transportation most desirable, and giving estimates for its cost.

Mr. Colonna has presented also a special report of the work during its earlier stages. In this



he expresses his thanks to Mr. Pratt for the spirit in which he came to his assistance in time of need, for the skill and energy with which he prosecuted the survey, and for his kindness and consideration to himself personally. Mr. Borden's services as aid were efficient and faithful.

Towards the end of May, 1885, in accordance with instructions, Mr. Colonna turned over the Yukon and all Coast and Geodetic Survey property on board of her in his charge to Mr. Pratt, and proceeded to Washington, stopping at Olympia, Washington Territory, long enough to acquaint Assistant J. J. Gilbert respecting the condition of the work on the Strait of Fuca, and to deliver to him such data as would enable him to continue it.

On June 8, he reported for duty at the office.

*Hydrographic survey of the Strait of Fuca.*—At the beginning of the fiscal year, as mentioned in the last annual report, a hydrographic survey in the Strait of Fuca was in active progress under the direction of Lieut. Commander A. S. Snow, Assistant Coast and Geodetic Survey, commanding the steamer Hassler. The lines run by the ship began in the near vicinity of Whidbey Island, and were carried across the strait, at intervals of two miles, as far as Pillar Point. In addition to these lines normal to the coast, two lines were run parallel to it; the various banks and shoals were developed, and close soundings were made in the vicinity of Puget Sound to connect with the inshore hydrographic work of previous seasons.

The boat work was carried on from New Dungeness light westward to Pillar Point; the lines being from one-third to one-fourth of a mile apart, with closer intervals wherever it seemed requisite. These lines were run out to a depth of twenty fathoms. Want of time prevented anything being done by the boats on the northern side of the strait except on Salmon Bank, which was quite closely and thoroughly sounded. Much trouble was experienced in getting the boats through the kelp, which grows very quickly in many localities, and the outer limit of which, as a rule, is in six fathoms water. No dangers were found outside of this kelp.

Lieutenant-Commander Snow gives in his report full details in regard to the harbors and anchorages within the limits of his hydrographic sheet. He observes that all of the anchorages are exposed to the easterly gales, but that these apparently do not blow home at Port Angelos, and from all other winds this harbor is admirably protected. He had been at anchor in the port when a heavy southeast gale was reported by telegraph twenty miles to the eastward, but with no indication of bad weather at his anchorage except a moderate swell, low barometer, and threatening sky. There is excellent holding ground, and good anchorage can be found anywhere on the southern side of the harbor.

The mountains of the Olympic Range, he remarks, have no special characteristic which can be described for the assistance of strangers navigating the strait, nor do the bluffs along the coast possess any peculiar features except in a few localities. At Pillar Point is a high round-topped hill, terminating in a high bare rock. Striped Peak, on the east side of Crescent Bay, is another conical hill, thickly wooded, and several hundred feet high. It has been conspicuous from a land slide, but the traces of this are gradually disappearing. These two points stand out quite prominently in the strait, the shore between them tending inward.

To obtain a plane of reference for the soundings, tide-gauges were put up at New Dungeness (just inside of the light), at Port Angelos, and at Griffin Bay, San Juan Island. Bench-marks were established for each gauge. Day and night observations for a lunar month were taken at Port Angelos. The gauge at this port was used for the greater part of the work, being more centrally located. Lieutenant-Commander Snow observes that the tides, although following the general law for the Pacific coast, are very irregular, and frequently perplexed him in endeavoring to follow them. It often happened in Port Angelos that there was no perceptible movement on the gauge for five or six hours, and but a few inches change throughout the day.

He suggests that a buoy on Salmon Bank would be a valuable aid to navigation, as the marks usually relied upon to keep clear of it cannot be seen at times when a buoy would be visible.

Respecting the currents in Fuca Strait, Lieutenant-Commander Snow remarks that they are very complex in their movements, and that observations of them to be of any value should extend over a long period, and be taken at regular intervals. As a rule, on the south side of the strait, with the flood tide, a vessel will be set slightly inshore of her compass course, while with the ebb, a set off-shore is noticed. Great caution should be used in the vicinity of the coast, especially

near Race Rock, Point Wilson, and other projecting points where tide-rips are marked, and where a small change in position will make much difference in the set of the current.

In the vicinity of the banks the currents split in various directions, and heavy tide-rips are common, especially with fresh westerly winds.

Work was discontinued October 17, and, in pursuance of instructions, the Hassler steamed to Victoria, British Columbia, to take on board the American consul at that port and convey him to Port Townsend, Seattle, and Nēēah Bay, Wash. T., returning thence with the consul to Victoria.

This service having been performed, the Hassler left Esquimalt, British Columbia, on October 28, and arrived at San Francisco November 2.

The zeal and intelligence in the execution of duty displayed by the naval officers attached to the party elicited the warm approbation of their commander. Signals were erected and observations made by Lieut. G. Blocklinger and by Ensigns W. V. Brounagh, F. M. Bostwick, and W. P. White. Records were kept by Passed Assistant Surgeon W. S. Dixon, and Assistant Engineer Edgar T. Warburton.

Following are the statistics of the season :

Miles run in sounding . . . . .	843
Angles measured . . . . .	3, 246
Number of soundings . . . . .	5, 025
Number of specimens of bottom preserved . . . . .	25

During the winter and spring the Hassler was thoroughly overhauled, and supplied with new boilers, a new false bottom under boilers and fire-room, &c. Towards the close of the fiscal year her commander was instructed to proceed to the coast of Oregon and continue the hydrography of that coast from a point near False Tillamook to the southward.

## SECTION XII.

### ALASKA, INCLUDING THE COAST AND ALEUTIAN ISLANDS. (Sketch No. 13.)

*Hydrographic surveys in Southeastern Alaska.*—At the date at which this report closes, Lieut. Richardson Clover, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Carlisle P. Patterson, was actively engaged in hydrographic surveys in the waters of Southeastern Alaska.

The Patterson left San Francisco April 25, 1885, and arrived at Port Simpson May 17. After landing material and working party for the steam tender Lively, and also a party for astronomical work, she proceeded the same day to Sitka to deliver a telegram from the Secretary of the Navy to the commanding officer of the U. S. steamer Pinta. On her return to Port Simpson May 26, the Lively and working parties were transferred to Ward's Cove, and on June 1 hydrographic work was begun on a sheet including Clarence Strait and the neighboring waters.

At the outset much difficulty was experienced in finding a site for a preliminary base line, the shores being densely wooded to high-water mark. After a thorough reconnaissance it was found necessary to go into Tongass Narrows, where a stretch of half a mile of beach was obtained at low water. The dense forests covering the approaches to the shores and the tops of the mountains made it impracticable to carry out a system of primary triangulation with long lines, and a series of small triangles had to be laid out, with frequent large signals at high-water mark.

Lieutenant Clover reports that the hydrographic characteristics of the locality are either very deep water or sunken rocks, which are frequently met with, and are exceedingly dangerous to navigation.

A staff gauge for tidal observations was put up in Ward's Cove June 5, and observations taken day and night until June 17. A similar gauge was put up at the same time in Karta Bay anchorage, and by simultaneous observations of four low and four high waters the curve of this gauge was connected with that at Ward's Cove, and found to be the same. At Karta Bay, tidal observations were continued till June 28. The plane of reference for the soundings, as determined by a mean of the lower low waters observed during twenty-three days, was found to be 1.57 feet above the zero of the staffs. The extreme rise and fall observed was twenty-two and one-quarter feet.

Statistics of work to the close of the fiscal year upon the hydrographic sheet, scale 1-80000, extending from Cape Chacon to Cape Onslow, and from the east coast of Prince of Wales Archipelago to Na-ah Bay, in Behm Canal, have been furnished by Lieutenant Clover, and are as follows.

Number of miles of shore line delineated .....	104
Number of stations occupied in triangulation .....	28
Miles run in sounding .....	82
Angles measured .....	458
Number of soundings.....	5,399

The following named officers of the Navy were attached to the party: Lieut. J. M. Helm, Ensigns Walter McLean, C. C. Marsh, D. P. Menefee, A. P. Niblack, and T. G. Dewey.

Subassistant R. A. Marr was ordered to duty on the Patterson early in April, and had special charge of the determinations of geographical position and the magnetic work. On the voyage up, Port Townsend, Washington Territory, was connected by telegraph with Mare Island Observatory. Time observations were taken at Port Townsend on four days, at Port Simpson, British Columbia, on eight days; at North Base Station, Ward's Cove, Alaska, on eight days; at Karta Bay, Alaska, one day. At the two stations last named approximate determinations of latitude were obtained.

Observations for the magnetic declination, dip, and intensity were made on five days at Port Simpson, British Columbia, and on three days at Karta Bay.

The further progress of this survey will be stated in the next annual report.

*Tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.*—

Assistant George Davidson, who has had the general supervision of the tidal work at Saint Paul, Kadiak Island, Alaska, reports that the record has been continuous, with the exception of a few breaks, unavoidable in training a new observer. For the first three months of the fiscal year, Mr. W. J. Fisher continued in charge of the gauge; he was succeeded by Mr. F. Sargent, who had already had some practice in managing it. The tabulations and original sheets are transmitted by the trading ships of the Alaska Commercial Company to San Francisco, and thence to Washington. Mr. Davidson acknowledges valuable assistance rendered to the new observer by Mr. Ivan Petroff, deputy collector of customs at Saint Paul.

### SECTION XIII.

#### KENTUCKY AND TENNESSEE. (Sketches Nos. 1, 4, 5, 15, 17, and 18.)

*Reconnaissance for extending the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio.*—Under the heading of Section III in this report an account has been given of the reconnaissance carried on by Assistant A. T. Mosman from stations in West Virginia westward near the thirty-ninth parallel into Kentucky and Ohio. Mr. Mosman was aided by Mr. J. E. McGrath. The reconnaissance was actively prosecuted until December 22, notwithstanding many interruptions from severe cold and storms. The scheme of triangulation resulting will be adopted for continuing the transcontinental geodetic work westward.

*Occupation of stations in continuation of the triangulation of the State of Tennessee.*—During the fiscal year the triangulation of the State of Tennessee was advanced by the occupation of four stations in the western part of the State by Prof. A. H. Buchanan, Acting Assistant. Instructions for field work were received July 9, 1884, and preparations were at once made for occupying station Deadeney, about twelve miles northwest of Spring City, Rhea County. The establishment of camp, the posting of heliotropers, &c., was completed by July 21, and on the 22d observations were begun. Smoke and haze were very prevalent, and it was not till August 25 that the work at this station could be completed.

The party was then moved to Owen station, two and a half miles northwest of Sweetwater, Monroe County. At this point observations were begun August 31, and completed September 19. House station, twelve miles northeast of Knoxville, was next occupied. Observations at "House" were finished November 5. The last station occupied in 1884 was Melton, near Burns' Mill, Roane County. At Melton the party spent seventeen days, but the atmosphere was so smoky that during most of that time it was impossible to see ten miles, and but two days and a half of clear working

weather were obtained. The exhaustion of the appropriation compelled Professor Buchanan to postpone the completion of the observations at Melton till another season. In June, 1885, this station was reoccupied, and the work there finished at the close of the fiscal year. At that date preparations for the occupation of another station were in progress.

## SECTION XIV.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN. (Sketches Nos. 1, 4, 14, 15, 17, and 18.)

*Reconnaissance for extending the primary triangulation near the thirty-ninth parallel into Ohio and Kentucky.*—Reference has been made under the heading of Section XIII, and a full account given under the heading of Section III, of the reconnaissance prosecuted by Assistant A. T. Mosman in November and December, 1884, for the extension of the transcontinental triangulation near the thirty-ninth parallel westward into Ohio and Kentucky. The most westward point reached in the reconnaissance was West Union, Adams County, Ohio, near which a station was selected, connecting with Peach Mount, Ohio, and Cherry Ridge, Ky.

*Continuation of the triangulation of the State of Ohio.*—Geodetic operations in the State of Ohio were resumed, under instructions, by Prof. R. S. Devol, Acting Assistant, early in July, 1884. On account of delay in the passage of the appropriation act, and the smallness of the allotment, the season was a brief one. Arrangements were made by Professor Devol to take the field with as little delay as possible; tripods and observing scaffolds were built at Buck Hill and Brown stations, and upon their completion the party was organized at Barton station, about eight miles southwest of the town of Logan, in Hocking County. Observations at Barton were continued till August 30, when field work was closed. The weather was unfavorable during the greater part of the period; a severe drought prevailed, with very hazy atmosphere, till August 21. Six stations were observed from Barton, and the total number of angular measurements was four hundred and eighty.

Earthen pyramids for underground marks and marble posts for surface marks were put down at Brown and Buck Hill stations, and marble posts for reference marks at Barton station. Measurements there will be resumed at the close of the fiscal year.

*Occupation of stations in continuation of the triangulation of the State of Indiana.*—Results of the field operations for the extension of the triangulation of the State of Indiana under the direction of Prof. J. L. Campbell, Acting Assistant, show the completion of measurements in the first quadrilateral, the occupation of two stations in the second quadrilateral, and a reconnaissance begun for the selection of stations in a third quadrilateral.

Four stations were occupied for angular measurements during the season—Blind Asylum Six-Mile Switch, Sims, and Lutz. By the occupation of the three stations first named, the surveys of the States of Indiana and Kentucky have been brought into close geodetic connection. Lutz is a station of the second quadrilateral north of the Ohio River. It is a few miles south of the town of Charlestown, Clark County, and is less than half a mile east of the line of the Ohio and Mississippi Railroad. At this station it was found necessary to erect a tripod and tower, forty feet in height. The other new station selected, but not occupied this season, was named Haystack. It is a little to the west of the town of Bennettsville, in Clark County; has an approximate elevation of nine hundred and ten feet above sea-level, and is a prominent and well-known part of the elevations known as "The Knobs."

Special care was taken to secure these stations by underground and surface markings. For the underground marks a one-eighth-inch copper wire was firmly set in cement in a black bottle, and the bottle placed in a ten-inch stone tubing and filled round firmly with gravel and cement two feet below the surface. Four limestone pillars were employed for the surface marks, one located directly over the center of the underground mark, and the three others six feet distant from the center, to the north, south, and east. These pillars are two feet long, dressed at top to five inches square, and show about four inches above the surface.

Field operations were closed in October. In the prosecution of the work Professor Campbell had efficient aid from Prof. J. N. Coulter. The statistics are:

Number of principal angles determined .....	12
Number of subordinate angles determined .....	9
Number of observations for principal angles .....	138

In June, 1885, work was resumed by Professor Campbell. He began a reconnaissance for advance stations, made a selection of one point, and at the end of the fiscal year was carrying forward the work of construction of an observing tripod and scaffold.

*Extension of the primary triangulation near the thirty-ninth parallel eastward across the State of Illinois.*—At the beginning of the fiscal year the primary triangulation near the thirty-ninth parallel in the State of Illinois had been advanced by Assistant George A. Fairfield nearly to the eastern boundary of the State. Before the first station could be occupied it became necessary to erect tripod and scaffold signals of seventy-five and eighty feet in height, one at Honey Creek station in Illinois and one at Summit station, Indiana. All preparations were completed by July 12, and the party of observation went into camp at Claremont station, which is situated four miles east and two miles north of Olney, Richland County.

On August 5, Assistant J. S. Bradford reported for duty in the party, and on the 24th, Extra Observer J. B. Boutelle joined it. Observations at Claremont were finished August 26, and a day or two later camp was moved to Hunt City station, which is about a mile northeast of the railroad station of the same name on the Danville, Olney and Ohio River Railroad. Twelve days sufficed to complete the work at Hunt City, and by September 26 the party was established in camp at Belle Air station, twelve miles south of Martinsville, on the Vandalia Railroad. A week of rainy weather delayed operations, but as only three directions had to be determined from this point, the occupation of the station was completed October 7, and on the 11th camp was pitched at Honey Creek station, about five miles northwest of Flat Rock, a small town on the Cairo division of the Wabash, Saint Louis and Pacific Railroad.

The next and last station occupied during the season was Summit, which is situated about nine miles northeast of Vincennes, Ind. Observations were begun November 4, but delays occurred, owing to the bad condition of the atmosphere and accidents to the night-observing-lights. On November 10, in pursuance of instructions, field work was closed for the season.

At three of the stations occupied signals had been erected in 1879 by the United States engineers, by whom a triangulation had been carried southward from stations of the Lake Survey. Mr. Fairfield found these signals to be in a good state of preservation. They had been built in the most substantial manner, and by occupying them he was enabled to make a very satisfactory connection between the Coast and Geodetic Survey transcontinental triangulation and that of the Engineer Corps, U. S. A. These stations were: Claremont, where the instrument was mounted at a height of eighty feet; Hunt City, where it was seventy-five feet, and Belle Air, where it was one hundred feet above the ground. Two of the lines in Mr. Fairfield's scheme, Denver to Claremont and Hunt City to Belle Air, were identical with lines of the Engineer Survey.

Three signals yet remain to be observed upon to carry the work entirely across the State of Illinois.

The statistics are:

Primary stations occupied .....	5
Primary signals observed upon .....	9
Secondary objects observed upon .....	8
Observations for horizontal directions .....	1,676

During the winter and spring Mr. Fairfield was occupied in office work, and towards the close of the fiscal year was directed to visit certain primary stations on the coast of Maine and report what steps would be necessary for their preservation. Subsequently he received instructions to resume work on the transcontinental triangulation.

*Progress made in connecting the line of transcontinental leveling with a point on the Gulf coast.*—In furtherance of the work of ascertaining the relative levels of the Atlantic and of the Gulf, by

running lines of leveling of precision from a point on the transcontinental line of levels towards Mobile, Assistant J. B. Weir proceeded, under instructions, to Odin, Marion County, Illinois, and on the 10th of April, 1885, began work from a bench-mark established by Assistant Braid in 1882. To make the starting point more secure, Mr. Weir established another permanent bench-mark at Odin.

From Odin the line of levels followed the track of the Illinois Central Railroad, and the trains of that road were used as a means of daily transportation to and from the localities of work. At Villa Ridge, Pulaski County, twelve miles north of Cairo, where field operations were closed June 5, two permanent bench-marks were established.

Between Odin and Villa Ridge, a distance of one hundred and nine miles, fourteen permanent bench-marks were established. The method of observing was the same as hitherto pursued in this work. Two parallel lines were run simultaneously and in the same direction with separate rods, these rods being placed at different distances from the level. In order to eliminate any cumulative error that might result from running constantly in one direction, alternate portions of the line, of ten or fifteen miles in length, were run in opposite directions, care being taken to have the back and fore sights as nearly equal as possible.

The original and duplicate records of the work have been transmitted to the office.

Mr. Weir, in his report, acknowledges the effective services rendered by Mr. John Nelson, who served as Aid in the party.

*Occupation of stations in continuation of the triangulation of the State of Wisconsin.*—In continuation of the triangulation of the State of Wisconsin, Prof. John E. Davies, Acting Assistant, took the field under instructions at the earliest date at which the appropriation became available. Between July 21 and October 28, when the season closed, four stations were occupied in the southeastern part of the State, and a connection was established with the triangulation of the U. S. Lake Survey. High tripods were built at Lebanon, Delafield, and Geneva Lake preparatory to the occupation of the first station, Oakland. Following this, stations Delafield, Erin, and Pleasant Springs were occupied in succession, and the occupation of station Lebanon attempted, but without success, owing to the vibration of the tall observing tripod and scaffold in the prevailing high winds. An effort will be made next year to give greater steadiness to this structure.

As the lines Lebanon-Erie-Delafield are all well established and adjusted lines of the Lake Survey, based upon carefully measured and fundamental lines at Fond-du-lac and Chicago, a close coincidence of results upon those lines would be highly gratifying, and was so, as far as the observations obtained would indicate.

Professor Davies devotes much space in his report to the recommendation of methods which appear to him highly desirable for greater efficiency and economy in the prosecution of the survey, and for the security of the stations already determined, especially those bordering upon the States of Iowa and Illinois, and upon Lake Michigan.

The statistics of his season's work are:

Number of horizontal angles measured . . . . .	83
Number of repetitions . . . . .	3,222
Number of vertical angles measured . . . . .	19
Number of repetitions . . . . .	684

## SECTION XV.

MISSOURI, KANSAS, IOWA, NEBRASKA, MINNESOTA, AND DAKOTA. (SKETCHES Nos. 2, 15, 17, and 18.)

*Occupation of stations for continuing to the westward the primary triangulation in Missouri and Kansas.*—At the beginning of the fiscal year Assistant F. D. Granger had organized his party in the field in Western Missouri for the continuation of the primary triangulation in Missouri and Kansas, and was occupied in superintending the construction of the high observing tripods and scaffolds required at the stations Haskin, Thomas, Bebe Mound, and Eckman. All of these stations are in the eastern part of Kansas, to the south, southwest, and west of Kansas City, Mo.

It became necessary, however, early in July, owing to the reduction of the appropriation for

the transcontinental work, to modify Mr. Granger's instructions, and to limit him to the occupation of two stations, Bowler and Berry, in Western Missouri, from which could be determined the first two stations of the scheme to the westward, Marty and Haskin.

Bowler station is on a small elevation, situated about two miles and a half southwest of the town of Lee's Summit, Jackson County, Missouri. Station Berry is about one mile and a half west of the town of Belton, Cass County, Missouri.

At Bowler the theodolite was elevated twenty-seven feet above ground, and five primary and eight tertiary directions were determined. At Belton the elevation of the theodolite was twenty-four feet. Observations were made upon four primary and six tertiary objects, and by September 1 all of the work required at the two stations was finished.

Before disbanding his party, Mr. Granger visited stations Haskin and Marty to secure them by permanent markings.

The tertiary objects determined were church spires in the towns of Harrisonville, Lee's Summit, Westport, Kansas City, and Independence.

The statistics are :

Number of observations for horizontal directions .....	922
Number of observations for elevations, by double zenith distances .....	98
Number of observations for differences of heights by micrometer .....	325

In September Assistant Granger was directed to report for duty in the party of Assistant A. T. Mosman. Mention of this service has already been made under the head of Section III. Upon being detached in October he was ordered to special duty at the office.

*Determination of the longitude of Kansas City, Mo.*—Under the heading of Section VIII an account has been given of the work of the two primary longitude parties, organized in March, 1885, for the determination in longitude of stations in Texas, Arkansas, and Missouri. Towards the end of May, Assistant Edwin Smith, who had been placed in general charge of the work, and in immediate charge of one of the primary parties, had determined the longitude of Little Rock, Ark., and had made the necessary arrangements for an exchange of telegraphic signals for longitude with Assistant C. H. Sinclair, in charge of the other primary party at Kansas City, Mo.

On the nights of May 30, 31, June 1 and 4 successful exchanges of longitude signals were obtained by the two observers. They then changed stations, Mr. Smith proceeding to Kansas City and Mr. Sinclair to Little Rock. In the new position of observers the determination of the longitude of Kansas City was completed by exchanges on the nights of June 11, 12, 18, and 19. The results for longitude of the primary points being freed from the effect of personal equation by the exchange of observers, no special observations were needed for personal equation between Messrs. Smith and Sinclair.

All of the records and field computations of the season's work have been transmitted to the office.

## SECTION XVI.

NEVADA, UTAH, COLORADO, ARIZONA, AND NEW MEXICO. (Sketches Nos. 2, 15, 16, 17, and 18.)

*Continuation of reconnaissance and triangulation in Utah, near the thirty-ninth parallel.*—Assistant William Eimbeck was engaged at the beginning of the fiscal year, as mentioned in my last annual report, in a reconnaissance for the site of a base line in Central Utah that should be so located as to be available for connection with the primary transcontinental triangulation near the thirty-ninth parallel. This work involved a reconnaissance of the mountains northeastward from Ogden, which was subsequently carried into the valley of the river Jordau and to the foot-spur mountains bordering that valley to the east. Mr. Eimbeck had in view also the extension of the geodetic scheme northward from the line Iupah—Mount Nebo. Having brought these examinations to a close early in July, and submitted for official decision two proposed locations for primary bases, he next carried a reconnaissance into the San Pitch Mountains, between Juab and San Pete Valleys, and thence to the Wasatch Plateau opposite the towns of Manti and Ephraim, San Pete County. All of this reconnaissance was virtually brought to a satisfactory conclusion by the end of July, and the results duly reported. These results were, the establishment of the intervisi-

bility of the points of the great quadrilateral, Ibepah (or Gosiute), Nebo, Pilot Peak, and Ogden, and a scheme of triangulation connecting the base-lines referred to with the main work.

In August Mr. Eimbeck submitted for consideration a scheme of telegraphic longitude stations covering a section of the arc of the thirty-ninth parallel from the meridian of Colorado Springs to the Pacific coast.

Upon the receipt in that month of telegraphic instructions approving and adopting the Juab base, he proceeded to organize a full party for the occupation of Scipio, one of the stations connecting with the south end of that base, and for the erection of the necessary signals to be observed upon at Cedar, Levan, San Pete, and South Juab. The plan of occupying Ibepah station was abandoned for the time being, owing to the advanced state of the season and the unusual isolation and inaccessibility of that mountain from the eastward.

Upon the 16th of August an advanced party was dispatched to Scipio station, a mountain upwards of five thousand feet in height, for the purpose of opening a trail for the pack animals, and by the end of that month the party was encamped near the summit, and the station was in readiness to receive the instruments. It was not, however, till the atmosphere had been cleared by a snow storm on the 10th of September that observations of horizontal directions could be begun. Heliotropes had been established at Nebo, Wasatch, and Mount Tushar; at all other stations flat, rectangular, and target-like signals were erected, such as had proved most effective as regards visibility on former occasions upon lines of fifty or sixty miles long.

At Scipio station the work included, besides observations of horizontal direction, observations of zenith distances, both absolute and differential, a complete set of magnetic and meteorological observations, and a rough topographical survey of the mountain, covering an area of at least ten square miles.

Before the close of field operations complete sets of magnetic observations, extending in each case over three days, were made at Deseret Railway station, Utah Central Railroad, and at Salt Lake City, where the Temple Block magnetic station was occupied to obtain the regular annual set of observations, this being deemed one of the base stations of the magnetic survey. At stations Nephi and Provo, which had been established and occupied the year before, the magnetic dip only was observed.

Field work was closed finally for the season in October, and, under instructions, Mr. Eimbeck proceeded to Washington and reported for duty at the office. The Aid in his party, Mr. George F. Bird, who had served creditably since being assigned to it, July 23, was detached and ordered to Kansas City. Mr. Bird had made all of the magnetic observations, the measurements of absolute zenith distance, and the topographical survey of Scipio station.

Owing to the shortness of the field season and unfavorable weather, the experiments with the "selenotrope," which Mr. Eimbeck had undertaken for the first time the preceding season to test the practicability of using the moon's light for geodetic night-signals, were not resumed, but will be as opportunity offers.

While engaged on office work during the remainder of the fiscal year Mr. Eimbeck submitted designs for a new form of base apparatus, and designed and reported also a new form of suspension for pendulums used for determinations of gravity.

Towards the end of June he received orders to prepare for the resumption of field work in Central Utah.

### SPECIAL OPERATIONS.

*Examination of methods of observation and photographic processes employed at the Magnetic Observatory, Toronto, Canada.*—Upon being relieved from the charge of the Magnetic Observatory at Los Angeles, Cal., Assistant Marcus Baker was ordered to proceed to Philadelphia and thence to Washington for conference with the Superintendent. Considerations based upon the desirability of improving the methods of photographic registry employed at Los Angeles led to the issue of instructions to Mr. Baker to proceed by way of Toronto, Canada, and obtain from Mr. Charles Carpmael, director of the Magnetic Observatory of the Dominion Government, permission to inspect the processes of photographic registry and development employed in that establishment.



On his journey east, Mr. Baker availed himself of a short stay at Kalamazoo, Mich., to determine the magnetic declination at that place.

Arriving in Toronto, August 25, Mr. Baker, finding the Director of the Observatory absent, was presented to Mr. James Young, his assistant, who had special charge of the magnetic work and the photographic processes, and was indebted to his courtesy for the privilege of examining the observatory and many of the details of its operations.

The results of this examination, and of studies and experimental investigations made during the winter and spring in Washington, with valuable aid and suggestions from Assistant Andrew Braid, led, in April, to a recommendation that argentic gelatino-bromide paper should be substituted for the bromo-iodide of silver paper then in use at Los Angeles. The change was effected, as stated under the heading of Section X, on the 1st of June, 1885, and the improvement in the character of the photographic traces has been very gratifying.

#### REPORTS IN REGARD TO THE SUBOFFICES AT BOSTON, NEW YORK, AND PHILADELPHIA.

*Suboffice at Boston.*—The relation of Assistant Henry Mitchell to certain harbor commissions in Massachusetts and other New England States led many years ago to the establishment of working rooms in Boston for himself and party. These rooms, two in number, came eventually to be a place for the collection of data, and for the computation of the results of physical surveys, and in 1881, under the new regulations issued in that year, were designated as a "suboffice."

Those that seek this suboffice, Mr. Mitchell reports, are mostly professional men, interested in commerce or navigation, and in the studies of physical hydrography there pursued; it is not, practically, a source of general information. He submits for consideration the conclusion that in view of the success of the work, the suboffice in Boston has been economically conducted, and under favorable conditions.

*Suboffice at New York.*—At the solicitation of the Chamber of Commerce, the Maritime Exchange, and the Produce Exchange of the city of New York, a suboffice was established in that city in May, 1885. The use of the building formerly occupied by the Produce Exchange, on Pearl, and Water, and Whitehall, and Moore Streets, was granted by that body free of charge to the Government. In view of the detailed resurvey of New York Harbor and its approaches, which was then in progress, and of the advantage of having a general headquarters where chiefs of parties could meet to arrange details of co-operation, and where charts of the harbor could be made accessible for reference, the Superintendent accepted with thanks the liberal offer of the Produce Exchange, and placed the arrangement and care of the office rooms in charge of Acting Assistant Francis J. Palmer.

It was believed also that the value of the work done by the Survey would have a wider recognition and more extended appreciation by the establishment of a suboffice in the most important maritime port of the United States.

At the date at which this report closes, part of Mr. Palmer's time was, occupied, with the approval of the Superintendent, in supervising the construction of a series of models, in relief, of the harbor and its approaches upon scales of three, eleven, and twenty-four inches to the mile, respectively. The expense of making these models was borne by members of the committee on harbor and shipping of the Chamber of Commerce. For the information of this committee Mr. Palmer had been previously engaged some months in examining and collating the various surveys of the harbor, and in collecting and arranging all of the publications which could be found bearing upon the subject.

The opening of this suboffice has developed the interest of all classes of the citizens of New York in the care, preservation, and improvement of the harbor, and has shown that they are heartily in sympathy with its thorough resurvey.

*Suboffice at Philadelphia.*—The use of a large and well-lighted room in the new post-office building in Philadelphia having been kindly accorded to the Survey, mainly through the efforts of Assistant S. C. McCorkle, the opportunity was taken of supplying a want long felt in some of the leading sea-ports, namely that of bringing the work and the results of the Survey into closer relations with the commercial and maritime community, and of establishing a bureau of information, where a supply of the charts and other publications could be kept for reference, and where inqui-

ries in regard to the operations of the work could either be answered or referred to the proper officers.

At the beginning of the fiscal year, Assistant McCorkle was instructed to take charge of this suboffice, and he has submitted a report of its operations to June 30, 1885. Applications for information have been received, and inquiries answered from the Department of Surveys of the city of Philadelphia, from the Water Department, the Board of Port Wardens, the Maritime Exchange, and the Board of Trade. Also from the officers of the Engineer Corps, U. S. A., of the Light-House Board, and Signal Service. Much advantage is derived from having the offices of these several Government bureaus under the same roof.

Those assistants of the Survey whose duty brought them to the city were afforded facilities for doing office work, and their instruments and records were stored temporarily, free of cost, in a fire-proof building. Assistants Henry Mitchell, R. M. Bache, C. M. Bache, C. T. Iardella, R. E. Halter, Edwin Smith, F. W. Perkins, H. L. Marindin, C. H. Sinclair, and C. H. Van Orden availed themselves from time to time of these facilities.

During the sessions of the American Association for the Advancement of Science, in September 1884, and during the period of the International Electrical Exhibition, in the autumn of that year, invitations were extended to the delegates and to the exhibitors to visit the office. Many responded and showed great interest in the charts, Coast Pilots, and tide-tables, and particularly in the model of the Depths of the Sea in the Bay of North America and Gulf of Mexico, which the Superintendent had sent for a time to the suboffice before placing it in the New Orleans Exposition.

A description of this model, with illustrative sketch, was given in Appendix No. 17 to the last annual report.

Mr. McCorkle expresses his belief that the interest of the public in the work of the Survey has been greatly advanced by the establishment of the suboffice in Philadelphia.

*Charge of the exhibit of the Coast and Geodetic Survey at the New Orleans Exposition.*—A special building for the use of the Government having been erected by the managers of the World's Industrial and Cotton Centennial Exposition held at New Orleans in 1884–1885, arrangements were made by the Treasury Department for exhibits by several of its Bureaus. Preparations were begun in the autumn of 1884 at this office for sending to New Orleans an exhibit which should illustrate the instruments and apparatus used in the Coast and Geodetic Survey, and the results of its work. Occasion was at the same time taken to prepare for transmission sets of Standards of Weight and Measure.

These preparations, under the general supervision of Assistant C. O. Boutelle, in charge of the office, were directed in detail by Assistant Henry W. Blair, who had been assigned to the charge of the exhibit of the Survey. Mr. Blair had arrived at Nashville early in December, having, with characteristic energy, started southward before having fully recovered from the effects of severe illness. At Nashville he was prostrated by an attack which proved fatal in a few days. Assistant George W. Dean was at once instructed to proceed to New Orleans, where he arrived December 17, and reported to Mr. William F. MacLennan, the representative of the Treasury Department in the Board of United States Executive Officers. Dr. James J. Clark, of the Office of Standard Weights and Measures, had already arrived and co-operated with Mr. Dean in the arrangements for the disposition of the exhibit, the space for which, though limited, was favorably located near the main entrance on the west side of the Government building.

The articles forming the exhibit were in place by the middle of January, 1885. They were classified under the heads of geodesy, astronomy, topography, hydrography, magnetics, miscellaneous, publications and results, and weights and measures.

The instruments and apparatus used in geodetic work were represented by the primary six-meter compensating base apparatus, by a four-meter secondary base apparatus, by two theodolites one sixteen inch and one eight inch, by reconnoitering telescopes, by heliotropes, by a geodesic level and a gradienter, and by signal lamps used for night observations.

The astronomical branch of the work was illustrated by a complete set of instruments used in determining latitude and longitude, and included a zenith telescope, a forty-six inch transit,

a prismatic transit, an electric chronograph, a break-circuit chronometer, telegraphic key-board, and apparatus for determining personal equation.

Topographic work was represented by a plane-table complete in all of its parts and a telemeter rod; hydrographic work by a sextant, and optical densimeter, a deep-sea thermometer, and a self-registering tide-gauge.

The instruments illustrating the magnetic branch of the Survey were a unifilar magnetometer and a dip-circle.

Under the head of "miscellaneous" were shown a pendulum, a geodesic level and rod, a maximum and minimum thermometer, a stoppered level, and a tripod and scaffold model for an observing signal.

The publications of the Survey were illustrated by a set of the volumes of annual reports and by copies of scientific papers, by volumes of the Coast Pilots for the Atlantic and Pacific coasts, by copies of tide tables, and by a catalogue of upwards of six hundred charts, with specimen copies of charts on the various scales of publication. Also by a model of the Depths of the Sea in the Bay of North America and Gulf of Mexico. A description of this model, with sketch, is given in Appendix 17 to the report for 1884.

Complete sets of standard weights and measures, according to the English system, as ordinarily used in the United States for commercial purposes, were exhibited; also a complete set of standards of weight and measure of the metric system, as legalized by act of Congress. Two comparators were shown, both for comparisons of end measures; one a vertical comparator, for the comparisons of end measures with a working standard during adjustment, the other a reflecting comparator, used for final comparisons of standards of length.

Several hundred copies of a pamphlet which had been prepared at the office, descriptive of the Coast and Geodetic Survey exhibit, were distributed to visitors who evinced special interest in the character and progress of the work.

Assistant Dean has submitted a full report of his connection with the exposition. Upon being relieved at his own request in March the charge of the exhibit was temporarily assigned to Dr. J. J. Clark, whose efficient and faithful services Mr. Dean acknowledges in his report. Towards the end of March Assistant C. H. Boyd was assigned to duty at New Orleans in place of Mr. Dean, and remained till the close of the exposition, May 31.

*Voyage of the new steamer C. P. Patterson from the Atlantic to the Pacific coast.*—Reference was made in the last annual report to the construction of a steamer, the Carlisle P. Patterson, specially designed for service on the Pacific coast. Before the Patterson left Hampton Roads for the Pacific, July 30, 1884, several trial trips were had with very satisfactory indications. Full reports have been submitted in regard to the results of her six months' voyage to the Pacific, the varying conditions of which compelled tests of her sea-going qualities much more complete and trustworthy than could be obtained in short trial trips. One of these reports has been prepared by Commander C. M. Chester, U. S. N., Hydrographic Inspector, who superintended the construction of the steamer. From the other report, submitted by her commander, Lieut. Richardson Clover, U. S. N., has been condensed the following account of her voyage from Montevideo to Valparaiso:

"The Patterson is of about eight hundred tons displacement, bark rigged, and capable of steaming nine knots on a consumption of eight tons of coal a day, and seven knots on four and one-half tons of coal a day in smooth water. Leaving Montevideo, Uruguay, at noon of November 6, 1884, with bunkers full and thirty tons of coal on deck, the steamer encountered a heavy gale near the mouth of the river, which compelled her to lay to the best part of a day, but though deeply loaded she rode quietly the heavy seas without taking anything but a little spray on deck. Variable weather with strong gales continued till the 14th, when the Straits of Magellan were entered with pleasant weather, the steamer passing between Virgin Reef and Nassau Rock."

Lieutenant Clover gives a detailed account of his passage through the straits, which at times was not unattended by danger. On the morning of the 17th, leaving his anchorage at an early hour, he passed down Famine Reach, and on rounding Cape Froward was met by a tempest blowing down Froward Reach. With a favorable current, he struggled against the wind and sea from 11 a. m. till 5 p. m., hoping that the wind would go down enough to allow him to get to Wood's Bay, if not to Port Gallant, but during these six hours he made but five miles. The wind was so violent that the

sea would be picked up bodily, and whirled into fine spray like a snow drift. At one time the wind got the vessel on the bow, and in order to keep her from running straight into the shore, her commander was compelled to back and wear short around, and came near losing both steam launches in bringing her again to the wind.

Two days later the Patterson steamed through Victory Pass into the Pacific.

While at anchor in the straits off Sandy Point, a town of fifteen hundred inhabitants, and the nearest town in the world to the South Pole, Captain Mendez, of the Argentine Navy, Military Governor of Staten Island and Terra del Fuego, visited the vessel, and from him much valuable information was obtained.

Off the Pacific coast soundings were taken with the deep-sea machine, and reported dangers searched for. On November 29 the Patterson reached Talcahuano, Chili, where she remained a week to refit, and December 7 left for Valparaiso, arriving at that port the next day. Immediately upon her arrival at San Francisco, February 13, 1885, Lieutenant Clover began preparations for the hydrographic work which had been assigned to him in Southeastern Alaska. A report of this work to the close of the fiscal year will be found under the heading of Section XII.

Commander Chester states that in the qualities needed for effective service in Alaskan waters the Patterson has exceeded his most sanguine expectations. He bases this conclusion upon the reports received from her commander, and upon an elaborate discussion of her stability, the data for which were obtained by experimental trials at the Washington Navy-Yard.

*Tidal observations at Honolulu, Sandwich Islands.*—Records have been received at this office up to June 28, 1884, from the self-registering tide-gauge loaned in 1877 for the use of the Hawaiian Government Survey. This gauge is in operation at Honolulu, Oahu, under the supervision of the Superintendent of that Survey, and its records will be of much value in the discussion of the tides of the Pacific.

#### COAST AND GEODETIC SURVEY OFFICE.

The report of the Assistant in charge of the Office, Charles O. Boutelle, esq., which appears in Appendix No. 4, and the accompanying reports of the chiefs of the office divisions, give all details relating to the office operations during the fiscal year.

Mr. Boutelle refers to the valuable contribution to our knowledge of the earth's magnetism made in Assistant Schott's paper on the secular variation and geographical distribution of the magnetic dip and intensity in the United States for the epoch, 1885. 0. Also to the improvements effected in the engraving, electrotyping, and printing divisions under the charge of Assistant Ogden. Improved batteries were introduced for electrotpe work, by means of which a more uniform and regular deposit of copper was obtained on the engraved plates, experiments having shown that a dynamo was not well adapted for this purpose. Increased facilities for the printers were obtained by an addition to the printing-office, affording better light and ventilation, and room for the new presses needed to meet the demand for charts.

In the tidal division, the tide-predicting machine, invented by Professor Ferrel, has proved to be of great value in reducing to a minimum the labor of computation. It was used largely in the preparation of the tide tables for the Atlantic and Pacific coasts for 1886, which are now published. Mr. Boutelle alludes to some records of exceptional interest received in the office during the year from three widely separated tidal stations in the Pacific Ocean. At the self-registering tide-gauges near San Francisco, at Kadiak in Alaska, and at Honolulu in the Sandwich Islands, the waves from the great Krakatoa earthquake of August 26, to September 2, 1883, were distinctly recorded. Photographic copies of these records, which will be of value in determining the movement of the earthquake waves, have been forwarded to the Royal Society, London.

The preparation of original topographic sheets for reproduction by photolithography has had special attention during the year in the Drawing Division and with marked success.

All calls for information received from the several Departments of the Government have been promptly met, and requests from private organizations or individuals for transcripts from the records of the Survey have when practicable been granted. A tabular statement of information

furnished is given in Appendix No. 3, and a table of the statistics of the Survey to the close of the fiscal year in Appendix No. 2.

The measurement of the areas of all salt and fresh marsh upon the Atlantic Gulf coast, alluded to in the last annual report as having been undertaken at the request and for the use of the Commissioner of Agriculture, was completed, and the results communicated to that officer.

Mr. Boutelle expresses his great personal indebtedness to Assistant H. W. Blair, who served as his immediate executive officer and adviser from the beginning of the fiscal year till he was seized with an illness which after a few months proved fatal. A tribute to the memory of this able young officer appears in Appendix No. 18.

Assistant C. H. Sinclair was temporarily assigned to duty in Mr. Blair's place, and served till relieved in August, 1884, by Subassistant F. H. Parsons, who remained on duty till the close of the fiscal year.

Mr. William H. Dall resigned his position as an Assistant in the Survey in September, 1884, in order to devote himself more exclusively to biological investigations. Mr. Dall had been connected with the Survey since 1871. His explorations in Alaska, resulting in his work, "Alaska and its Resources," published in 1870, and his assignment to duty on that remote coast for a number of years after his appointment, caused him to be recognized as an authority in all matters pertaining to the territory. In 1879 the Survey published as an Appendix to the Pacific Coast Pilot an elaborate work, compiled and edited by him, on the meteorology of Alaska, with a partial list of maps and charts relating to it and the adjacent regions, and an exhaustive bibliography. In 1883, under his editorship, the Survey published the Alaska Coast Pilot, Part I, from Dixon Entrance to Yakutat Bay.

For valuable aid in the preparation of these works, Mr. Dall acknowledges his obligations to Assistant Marcus Baker, who had served with him on the Alaskan peninsula. After Mr. Dall's resignation took effect, all Alaskan material in his hands was turned over to Mr. Baker, and by direction of the Superintendent he was charged with the revision of charts and sailing directions resulting from hydrographic reconnaissances in the Alexander Archipelago. He was occupied also during the winter and spring with tidal investigations and special correspondence relating to the tides. In October he was instructed to visit Sandy Hook automatic tide-gauge and restore its efficiency, and in February, 1885, he prepared a preliminary report upon the character and condition of all tidal observations obtained in the Survey to the close of 1884. In May he was assigned to duty on the New York Harbor resurvey.

Reference was made in the report for 1883 to the detail of Subassistant E. D. Preston as a member of the Eclipse Expedition to Caroline Island, South Pacific Ocean, and to his return to San Francisco, and the comparative determinations of gravity made by him in July and August, 1883, at the station in that city established by Assistant Davidson.

In the report for 1884 it should have been stated that Mr. Preston, upon being ordered to the Atlantic coast, was employed on miscellaneous duty in the office of the Superintendent from September 1, 1883, to January 15, 1884. During this time he investigated the relative accuracy of superposition and contact in micrometric pointings; determined the equatorial intervals of transit No. 5 for the use of the French Transit of Venus Commission; reviewed the longitude work between Savannah, Ga., and Saint Augustine, Fla., and finished his computations for the report of Professor Holden on the Total Solar Eclipse of May 6, 1883.

On January 15, 1884, Mr. Preston was granted six months furlough to proceed to Cordoba, Argentine Republic, South America, to aid Dr. Gould on his work on the Southern Stars.

In the office of Assistant in charge the clerical duties were very acceptably discharged by Dr. W. B. French, who had also the entire care of the office accounts, including the returns of money received for sales of charts.

Mr. W. B. Chilton served as clerk and Mr. C. D. Gedney as stenographer in the office of the Superintendent.

Mr. W. B. Morgan continued on duty as disbursing agent of the Survey, with Mr. J. W. Parsons as accountant and Mr. V. J. Fagin as examiner.

## CONCLUSION.

In the preparation of this report, and in the editing for publication of the last annual report and appendices thereto, Assistant Edward Goodfellow rendered service throughout the year. The report for the fiscal year ending with June, 1884, a volume of upwards of six hundred pages quarto, with twenty-five progress sketches and illustrations, ordered printed by Congress in February, 1885, was published in November, and is now ready for distribution. Extra copies of papers of special interest or practical value to surveyors, geodesists, and others, published as appendices to this report, had previously been supplied by the Public Printer.

Events which led to my appointment as Superintendent in July last, and subsequently to the resignation by Mr. J. E. Hilgard of that position, have devolved upon me the duty of presenting this report to the Department.

Respectfully submitted.

F. M. THORN,  
*Superintendent.*

HON. DANIEL MANNING,  
*Secretary of the Treasury.*



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PART III.

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APPENDICES.

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## APPENDIX No. 1.

*Distribution of the parties of the Coast and Geodetic Survey upon the Atlantic, Gulf of Mexico, and Pacific coasts, and in the interior of the United States during the fiscal year ending with June, 1885.*

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
<b>SECTION I.</b> <b>Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island, including coast and seaports, bays and rivers.</b>	No. 1	Topography .....	Charles H. Boyd, assistant; Henry R. Taylor.	Machias Bay entrance, Machiasport and coast to the eastward.
	2	Topography .....	Eugene Ellicott, assistant; J. H. Turner, aid.	Chandler's Bay and Englishman's Bay shore-lines, coast of Maine. (See also Sections III and VI.)
	3	Hydrography .....	Lieut. E. D. F. Heald, U. S. N., assistant; Ensigns T. D. Griffin, A. Jeffries, and W. C. Canfield, U. S. N.	Narragausus River, Harrington River, and Pleasant Bay and river, Maine. (See also Sections VI and VIII.)
	4	Topography .....	A. W. Longfellow, assistant, E. F. Dickins, assistant.	Prospect Harbor and Mount Desert Island, Maine.
	5	Tidal observations	J. G. Spaulding .....	Record of observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay.
	6	Hydrographic examinations.	Lieut. J. E. Pillsbury, U. S. N., assistant.	Coasts of Maine, New Hampshire, and Massachusetts. (See also Section VI.)
	7	Geodetic operations.	Prof. E. T. Quimby, acting assistant.	Continuation of the triangulation of the State of New Hampshire.
	8	Geodetic operations.	Prof. V. G. Barbour, acting assistant.	Occupation of stations in continuation of the triangulation of the State of Vermont.
	9	Special triangulation.	Henry L. Whiting, assistant, and commissioner for the State of Massachusetts; Gershom Bradford, assistant; F. W. Perkins, assistant; C. H. Van Orden, subassistant.	Trigonometrical operations in aid of a topographical survey of the State of Massachusetts.
	10	Hydrographic examinations.	Lieut. Commander W. H. Brownson, U. S. N., assistant; Lieut. F. H. Crosby, U. S. N.; Ensigns P. J. Werlich, William Truxtun, E. Simpson, jr. and M. C. Gorgas, U. S. N.	Coasts of Massachusetts and Rhode Island (See also Section II.)
	11	Magnetic observations.	James B. Baylor, subassistant....	Magnetic stations at Providence and on Coasters Harbor Island. (See also Section II.)
	12	Hydrographic examinations.	Ensign A. F. Fechteler, U. S. N., assistant; Ensigns F. W. Kellogg, and F. R. Brainard, U. S. N.	In the approaches to Newport, R. I. (See also Sections II and III.)
	13	Tidal observations	.....	Observations continued at Providence, R. I., with a self-registering tide-gauge loaned to the city engineer.

## APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II. Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including coast, bays, and rivers.	No. 1	Topography .....	Charles Hosmer, assistant; W. I. Vinal, subassistant.	Topographical resurvey of the northeastern coast of Long Island in the vicinity of Gardiner's Bay, Shelter Island, and Greenport; also of the north shore of the Sound from Darien, Conn., northward.
	2	Topography .....	W. I. Vinal, subassistant.....	Continuation of the topographical resurvey of the north shore of Long Island to the west of Greenport.
	3	Hydrographic examinations.	Ensign A. F. Fechteler, U. S. N., assistant; Ensigns F. W. Kellogg and F. R. Brainard, U. S. N.	Hydrographic work off Terry Point and Rocky and Horton's Points, Long Island. (See also Sections I and III.)
	4	Topography .....	W. C. Hodgkins, subassistant.....	Topographical resurveys at the mouth of the Connecticut River, and near Milford and Stratford, on the north shore of Long Island Sound; also from Lloyd's Neck eastward, on the south shore.
	5	Topography .....	W. H. Dennis, assistant; C. H. Van Orden, subassistant; J. W. Dudley, acting aid.	Continuation of the topographical resurvey of the north shore of Long Island Sound in the vicinity of Madison, Guilford, and Branford, Conn.
	6	Hydrography.....	Lieut. W. G. Cutler, U. S. N., assistant; Ensigns F. H. Sherman and J. S. Watters, U. S. N.	Inshore hydrographic survey of the northern coast of Long Island Sound from Hammonasset Point to Welch's Point.
	7	Tidal observations .....		Tidal observations with an automatic gauge at the light-house on the New Haven Breakwater.
	8	Topography .....	E. Hergesheimer, assistant .....	Continuation of the topographic resurvey of the north shore of Long Island Sound from Frost (or Farms) Point westward. Topographical resurvey of shores of East River.
	9	Triangulation .....	Gershom Bradford, assistant .....	Triangulation in the western part of Long Island Sound extended from Lloyd's Neck towards New Rochelle. (See also Section I.)
	10	Topography .....	Charles Hosmer, assistant .....	Topographical resurvey of the north shore of Long Island Sound continued from Darien, Conn., towards New Rochelle, N. Y.
	11	Topography .....	E. Hergesheimer, assistant.....	Topographical resurvey of the shores of East River, New York.
	12	Hydrography.....	Lieut. J. M. Hawley, U. S. N., assistant.	Hydrographic resurvey of the East River, New York.
	13	Triangulation .....	E. F. Dickins, assistant .....	Determination of points for the resurvey of New York Lower Bay.
	14	Topography .....	J. Hergesheimer, assistant.....	Topographic resurvey of the shore lines of Coney Island and Rockaway Beach, New York lower bay. (See also Section VI.)
	15	Hydrography.....	Lieut. G. C. Hanus, U. S. N., assistant.	Hydrographic resurvey of the entrance to New York Bay. (See also Sections V and VI.)
	16	Topography .....	D. B. Wainwright, assistant.....	Topographic resurvey of the shores of the North River, New York. (See also Section III.)
	17	Hydrography.....	Lieut. W. G. Cutler, U. S. N., assistant.	Hydrographic resurvey of the North River, New York.
	18	Physical hydrography.	Henry Mitchell, assistant; H. L. Marindin, assistant; Marcus Baker, assistant.	Development of plans for the study of the physical hydrography of New York Bay and Harbor.
	19	Tidal observations .....		Records of observations with self-registering tide-gauges at Governor's Island and at Sandy Hook.
	20	Topography .....	E. L. Taney, aid .....	Topographical resurvey of Sandy Hook.
	21	Geodetic operations.	Prof. E. A. Bowser, acting assistant.	Extension of reconnaissance and triangulation in the southern part of the State of New Jersey.
	22	Geodetic operations.	Prof. Mansfield Merriman, acting assistant; O. H. Tittmann, assistant.	Extension of reconnaissance and triangulation in the eastern half of the State of Pennsylvania.

## APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II—Continued.	No. 23	Geodetic operations.	Prof. L. H. Barnard, acting assistant.	Reconnaissance for triangulation in the western half of the State of Pennsylvania.
	24	Triangulation ....	Spencer C. McCorkle, assistant; C. H. Sinclair, assistant; C. H. Van Orden, subassistant.	Special triangulation for the city of Philadelphia.
	25	Physical hydrography.	Henry Mitchell, assistant; Henry L. Marindin, assistant.	Physical hydrography of Delaware River and Bay.
	26	Triangulation ....	F. W. Perkins, assistant; C. H. Van Orden, subassistant.	Special triangulation. Delaware River, from Petty's Island to Poquessink Creek. (See also Section VIII.)
	27	Magnetic observations.	Edwin Smith, assistant .....	Magnetic observations at Philadelphia. (See also Sections VIII, IX, and XV.)
	28	Hydrographic examinations.	Lieut. Commander W. H. Brownson, U. S. N., assistant; Ensign M. C. Gorgas, U. S. N.	Determination of position of wreck off Barnegat. (See also Section I.)
	29	Triangulation, reconnaissance, and magnetic observations. Continuation of topographic survey.	C. M. Bache, assistant; J. B. Baylor, subassistant.	Continuation of triangulation and reconnaissance on the New Jersey coast. Magnetic station occupied on that coast, and topographic survey continued.
	30	Topography .....	R. M. Bache, assistant; E. L. Taney, aid.	Topographical resurvey of the New Jersey shore of Delaware Bay continued.
	31	Topography .....	C. T. Iardella, assistant .....	Completion of the topographical resurvey of the western shore of Delaware Bay.
	32	Hydrography .....	Lieut. G. C. Hanus, U. S. N., assistant; Ensigns A. L. Hall, J. H. Hetherington, E. F. Leiper, and G. R. French, U. S. N.	Continuation of the hydrographic resurvey of Delaware entrance. (See also Sections V and VI.)
SECTION III.				
Maryland, District of Columbia, Virginia, and West Virginia, including bays, seaports, and rivers.	No. 1	Determinations of gravity.	C. S. Peirce, assistant .....	Gravity determinations and experimental researches at Washington, D. C., and in Virginia. (See also Section VI.)
	2	Magnetic observations.	Charles A. Schott, assistant ....	Annual determination of the magnetic declination, dip and intensity at a station on Capitol Hill, Washington.
	3	Topography .....	John W. Donn, assistant; D. B. Walwright, assistant.	Continuation of the detailed topographical survey of the District of Columbia.
	4	Geodesic leveling.	John B. Weir, assistant; John Nelson, aid.	Lines of leveling of precision carried from Ashland, Va., to Fortress Monroe. (See also Section XIV.)
	5	Special survey .....	Charles Junken, acting assistant.	Determination of points on the boundary line between Maryland and Virginia.
	6	Hydrographic examinations.	Ensign A. F. Fechteler, U. S. N., assistant.	Hydrographic examinations off Cape Henry, Va. (See also Sections I and II.)
	7	Topography .....	Eugene Ellicott, assistant .....	Supplementary topographical survey between Norfolk and the ocean shore. (See also Sections I and VI.)
	8	Reconnaissance and triangulation.	A. T. Mosman, assistant; F. D. Granger, assistant; Prof. J. H. Gore, volunteer assistant; W. B. Fairfield, extra observer; J. E. McGrath, aid.	Extension of the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio.
SECTION V.				
South Carolina and Georgia, including coast, seawater channels, sounds, harbors, and rivers.	No. 1	Hydrography .....	Lieut. G. C. Hanus, U. S. N., assistant; Ensigns E. F. Leiper, F. R. Brainard and George R. French, U. S. N.	Hydrographic survey in Stono and Wadmelaw Rivers, South Carolina. (See also Sections II and VI.)

## APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
<b>SECTION VI.</b>				
Peninsula of Florida, from Saint Mary's River, on the east coast, to and including the Anclote Keys on the west coast, with the coast approaches, reefs, keys, seaports and rivers.	No. 1	Triangulation and topography.	Eugene Ellicott, assistant .....	Triangulation and shore-line topography of Saint John's River from Palatka to Nine-mile Point. (See also Sections I and III.)
	2	Hydrography ....	Lieut. G. C. Hanna, U. S. N., assistant; Ensign E. F. Leiper, U. S. N., assistant; Ensigns F. R. Brainard and G. R. French, U. S. N.	Hydrographic survey of Saint John's River from Racy Point to Palatka. (See also Sections II and V.)
	3	Physical hydrography.	Lieut. J. E. Pillsbury, U. S. N., assistant; Ensigns A. F. Fechter, P. J. Werlich, W. A. Thom, William Truxtun, E. Simpson, and M. C. Gorgas, U. S. N.	Deep sea soundings in N. W. Providence Channel, and in Gulf Stream off Florida coast, and subcurrent observations in Gulf Stream between Fowey Rocks and Gun Cay, Bahamas. (See also Section I.)
	4	Determination of gravity.	C. S. Peirce, assistant; W. B. Fairfield, extra observer.	Determination of gravity at Key West. (See also Section III.)
	5	Beach measure and topography.	Joseph Hergesheimer, assistant; J. H. Turner, aid.	Beach measure and topography on west coast of Florida from Bowditch Point to Cape Romano. (See also Section II.)
	6	Hydrography ....	Lieut. E. D. F. Heald, U. S. N., assistant; Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N.	Hydrographic survey of the west coast of Florida from the vicinity of Gordon's Pass to Cape Romano. (See also Sections I and VIII.)
<b>SECTION VIII.</b>				
Alabama, Mississippi, Louisiana, and Arkansas, including Gulf coasts, ports, and rivers.	No. 1	Reconnaissance...	O. H. Tittmann, assistant; George F. Bird, aid.	Continuation of reconnaissance for the connection of the triangulation of the Gulf coast with that along the Blue Ridge. (See also Section II.)
	2	Hydrography ....	Lieut. E. D. F. Heald, U. S. N., assistant; Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N.	Hydrographic work in Mobile Bay and around the Chandeleur Islands. (See also Sections I and VI.)
	3	Telegraphic longitudes.	Edwin Smith, assistant; C. H. Sinclair, assistant; E. D. Preston, subassistant.	Determination of the longitudes of Little Rock, Texarkana, and Fort Smith, Arkansas. (See also Sections IX, XV, and XVI.)
	4	Triangulation and topography.	F. W. Perkins, assistant, E. L. Taney, aid; Richard C. Wilson, volunteer aid.	Triangulation and topography of the coast of Louisiana from Côté Blanche Bay to the westward. (See also Section I.)
	5	Hydrography ....	Lieut. F. H. Crosby, U. S. N., assistant; Ensigns T. M. Brumby, A. L. Hall, J. H. Hetherington, and J. S. Watters, U. S. N.	Hydrographic survey off the coast of Louisiana from Sabine Pass eastward.
<b>SECTION IX.</b>				
Texas and Indian Territory, including Gulf coast, bays, and rivers.	No. 1	Telegraphic longitudes.	Edwin Smith, assistant; E. D. Preston, subassistant.	Determination of the longitude of Brownsville Texas. (See also Sections VIII, XV, and XVI.)
	2	Triangulation ....	R. E. Halter, assistant .....	Triangulation and wire-measurement between Point Isabel and Brownsville, Texas.
<b>SECTION X.</b>				
California, including the coast, bays, harbors, and rivers.	No. 1	Triangulation ....	A. F. Rodgers, assistant .....	Survey of the coast-line, connecting the work at San Juan Capistrano with that at Newport Bay.
	2	Magnetic observations.	Marcus Baker, assistant; Carlisle Terry, jr., aid.	Series of observations continued at the magnetic self-registering record station at Los Angeles, Cal.

## APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION X—Continued.	No. 3	Triangulation ....	James S. Lawson, assistant; P. A. Welker, aid.	Continuation of the primary triangulation of the coast of California north of Point Concepcion.
	4	Triangulation and topography.	Stebman Forney, assistant .....	Survey of the coast of California continued from Moro Bay eastward.
	5	Hydrography.....	Lieut. E. D. Taussig, U. S. N., assistant; Lieut. F. H. Lefavor, U. S. N.; Ensigns W. L. Burdick and P. B. Bibb, U. S. N.	Hydrographic survey of the California coast in the vicinity of San Simeon.
	6	Triangulation ....	George Davidson, assistant; R. A. Marr, subassistant; Fremont Morse, aid; C. B. Hill, acting aid.	Occupation of stations in continuation of the primary triangulation of the coast of California.
	7	Tidal observations	E. Gray, tidal observer.....	Self-registering tide gauge record kept up at Saucelito, San Francisco Bay.
	8	Hydrography .....	Lieut. E. D. Taussig, U. S. N., assistant; Ensigns J. N. Jordan, W. L. Burdick, J. A. Bell, and F. A. McNutt, U. S. N.	Hydrographic surveys on the California coast in Humboldt Bay and between Brushy Point and White Rock.
SECTION XI.				
Oregon and Washington Territory, including coast, interior bays, ports, and rivers.	No. 1	Triangulation and topography.	Louis A. Sengteller, assistant....	Survey of the Umpquah River, Oregon.
	2	Topography and hydrography.	Cleveland Rockwell, assistant ...	Continuation of the topographical survey of the Columbia and Willamette Rivers. Hydrography of the Willamette River.
	3	Topography and reconnaissance.	J. J. Gilbert, assistant.....	Completion of the topography of Hood's Canal, W. T. Reconnaissance of the Olympic Mountains.
	4	Hydrography.....	Lieut. C. F. Forse U. S. N., assistant; Ensign J. N. Jordan, U. S. N., assistant.	Hydrographic surveys in Hood's Canal, W. T.
	5	Triangulation and topography.	J. F. Pratt, assistant.....	Triangulation and topography of Possession Strait and Sound, W. T.
	6	Reconnaissance and triangulation.	B. A. Colonna, assistant; J. F. Pratt, assistant.	Reconnaissance for the triangulation of the Strait of Fuca.
	7	Hydrography.	Lieut. Commander A. S. Snow, U. S. N., assistant; Lieut. G. Blocklinger, U. S. N.; Ensigns W. V. Brounagh, F. M. Bestwick, and W. P. White, U. S. N.	Hydrographic survey of the Strait of Fuca.
SECTION XII.				
Alaska, including the coast and the Aleutian Islands.	No. 1	Hydrography.....	Lieut. Richardson Clover, U. S. N., assistant; Ensigns W. McLean, C. C. Marsh, D. P. Menefee, T. G. Dewey, and A. P. Niblack, U. S. N.	Hydrographic surveys in Southeastern Alaska.
	2	Tidal observations	W. J. Fisher and F. Sargent.....	Tidal observations continued with self-registering tide-gauge at Saint Paul, Kodiak Island, Alaska.
SECTION XIII.				
Kentucky and Tennessee..	No. 1	Reconnaissance and triangulation.	A. T. Mosman, assistant; J. E. McGrath, aid.	Reconnaissance for extending the primary triangulation near the 39th parallel from West Virginia into Kentucky and Ohio.
	2	Geodetic operations.	Prof. A. R. Buchanan, acting assistant.	Occupation of stations in continuation of the triangulation of the State of Tennessee.
SECTION XIV.				
Ohio, Indiana, Illinois, Michigan, and Wisconsin.	No. 1	Reconnaissance and triangulation.	A. T. Mosman, assistant; J. E. McGrath, aid.	Reconnaissance for extending the primary triangulation near the 39th parallel into Ohio and Kentucky.

## APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION XIV—Continued.	No. 2	Geodetic operations.	Prof. R. S. Devol, acting assistant.	Continuation of the triangulation of the State of Ohio.
	3	Geodetic operations.	Prof. J. L. Campbell, acting assistant; Prof. J. M. Coulter, recorder.	Occupation of stations in continuation of the triangulation of the State of Indiana.
	4	Triangulation.....	George A. Fairfield, assistant; J. S. Bradford, assistant; J. B. Bontelle, extraobserver; F. B. Bacon, recorder.	Extension of the primary triangulation near the 39th parallel eastward across the State of Illinois.
	5	Geodesic leveling.	John B. Weir, assistant; John Nelson, aid.	Progress made in connecting the line of transcontinental leveling with a point on the Gulf coast.
	6	Geodetic operations.	Prof. J. E. Davies, acting assistant.	Occupation of stations in continuation of the triangulation of the State of Wisconsin.
SECTION XV. Missouri, Kansas, Iowa, Nebraska, Minnesota, and Dakota.	No. 1	Triangulation.....	F. D. Granger, assistant.....	Occupation of stations for continuing to the westward the primary triangulation near the 39th parallel in Missouri and Kansas.
	2	Telegraphic longitudes.	Edwin Smith, assistant; C. H. Sinclair, assistant.	Determination of the longitude of Kansas City, Mo.
SECTION XVI. Nevada, Utah, Colorado, Arizona, and New Mexico.	No. 1	Reconnaissance and triangulation.	William Eimbeck, assistant; U. F. Bird, aid.	Continuation of reconnaissance and triangulation in Utah near the 39th parallel.
SPECIAL OPERATIONS.		Examination of methods of observation and photographic processes employed at the Magnetic Observatory, Toronto, Canada.	Marcus Baker, assistant.....	
		Reports in regard to the suboffices at Boston, New York, and Philadelphia.	Henry Mitchell, assistant; F. J. Palmer, acting assistant; S. C. McCorkle, assistant.	
		Charge of the exhibit of the Coast and Geodetic Survey at the New Orleans Exposition.	George W. Dean, assistant; C. H. Boyd, assistant; J. J. Clark, mechanician.	
		Voyage of the new steamer C. P. Patterson from the Atlantic to the Pacific coast.	Lieut. Richardson Clover, U.S.N., assistant.	
		Tidal observations at Honolulu, Sandwich Islands.	Superintendent of Hawaiian Government Survey.	

## APPENDIX No. 2.

*Statistics of field and office work of the Coast and Geodetic Survey for the year ending June 30, 1885.*

	Total to June 30, 1884.	Total during fiscal year.	Total to June 30, 1885.
<b>RECONNAISSANCE.</b>			
Area in square statute miles .....	331 100	46 860	377 960
Parties, number of .....		4	
<b>BASE LINES.</b>			
Primary, number of .....	14	0	14
Primary, length in statute miles .....	90	0	90
Subordinate, number of .....	129	1	130
Subordinate and beach measures, length of .....	442	34	476
<b>TRIANGULATION.</b>			
Area in square statute miles .....	193 420	6 444	199 864
Stations occupied for horizontal measures, number of .....	10 698	382	11 080
Geographical positions determined, number of .....	20 478	627	21 105
Stations occupied for vertical measures, number of .....	682	80	762
Elevations determined trigonometrically, number of .....	1 783	132	1 915
Heights of benchmarks by spirit-leveling, number of .....	2 689	325	3 014
Lines of spirit-leveling, length of, in statute miles .....	2 933	397	3 330
Triangulation and leveling parties, number of .....		30	
<b>ASTRONOMICAL WORK.</b>			
Azimuth stations, number of .....	187	3	190
Latitude stations, number of .....	312	6	318
Longitude stations, telegraphic, number of .....	124	3	127
Longitude stations, chronometric or lunar, number of .....	110	0	110
Astronomical parties, number of .....		6	
<b>MAGNETIC WORK.</b>			
Stations occupied, number of .....	675	18	693
Permanent magnetic stations, number of .....		2	
Magnetic parties, number of .....		7	
<b>TOPOGRAPHY.</b>			
Area surveyed, in square statute miles .....	29 134	1 147	30 281
Length of general coast in statute miles .....	6 728	14	6 742
Length of shore-line, in statute miles, including rivers, creeks, and ponds .....	84 510	1 905	86 505
Length of roads, in statute miles .....	42 423	1 829	44 252
Topographical parties, number of .....		25	
<b>HYDROGRAPHY.</b>			
Parties, number of .....		15	
Number of miles (geographical) run while sounding .....	369 415	8 810	378 225
Area sounded, in square geographical miles .....	95 335	4 245	99 580
Miles run, additional of outside or deep-sea soundings .....	74 748	508	75 256
Number of soundings .....	16 684 410	322 918	17 007 328
Deep-sea soundings .....	12 936	154	13 090
Deep-sea temperature observations .....	11 801	209	12 010
Current stations, number of .....	615		
Deep-sea current stations, number of .....		17	
Deep-sea sub-current observations, number of .....		1 059	
Deep-sea surface current observations, number of .....		2 826	



## APPENDIX No. 2—Continued.

	Total to June 30, 1884.	Total during fiscal year.	Total to June 30, 1885.
<b>HYDROGRAPHY—Continued.</b>			
Specimens of bottom, number of.....	12 338	290	12 628
Automatic tide gauges established * .....	82	3	85
Automatic tide gauges discontinued * .....	78	1	79
Staff and box gauges established * .....	1 610	34	1 644
Staff and box gauges discontinued * .....	1 606	33	1 639
Parties doing tidal work exclusively * .....		4	
Parties doing tidal in connection with hydrographic work * .....		18	
<b>RECORDS.</b>			
Triangulation, originals, number of volumes .....	4 305	277	4 582
Astronomical observations, originals, number of volumes .....	1 738	59	1 797
Magnetic observations, originals, number of volumes .....	563	64	627
Duplicates of above, number of volumes .....	4 547	370	4 917
Computations, number of volumes .....	3 819	156	3 975
Hydrographic soundings and angles, originals, number of volumes .....	9 020	302	9 322
Hydrographic soundings and angles, duplicates, number of volumes .....	1 895	280	2 175
Tidal and current observations, originals, number of volumes .....	3 592	94	3 686
Tidal and current observations, duplicates, number of volumes .....	2 346	56	2 402
Aggregate years of record from automatic tide gauges * .....	246	5	251
Tidal stations for which reductions have been made * .....	929	36	965
Aggregate years of record reduced * .....	204	4	208
<b>MAPS AND CHARTS.</b>			
Topographic maps, originals .....	1 669	9	1 678
Hydrographic charts, originals .....	1 759	58	1 817
Reductions from original sheets .....	945	17	962
Total number of manuscript maps and charts .....	2 706	19	2 725
Number of sketches made in field and office .....	3 246	36	3 282
<b>ENGRAVING AND PRINTING.</b>			
Engraved plates of finished charts, number of .....	274	11	285
Engraved plates of preliminary charts, sketches and diagrams for the Coast and Geodetic Survey reports, number of .....	650	1	651
Electrotype plates made .....	1 758	66	1 824
Finished charts published .....	408	11	419
Engraved plates of Coast Pilot charts .....	77	3	80
Engraved plates of Coast Pilot views .....	88	1	89
Printed sheets of maps and charts distributed .....	549 425	14 870	564 295
Printed sheets of maps and charts deposited with sale agents .....	229 480	14 085	243 515
Charts published by photolithography .....		16	

\* The form in which tidal statistics have been presented in preceding reports is here superseded by one, which, although it shows no diminution in the amount of field work done, is believed to exhibit that amount more distinctly, and to be much less liable to erroneous interpretation. An additional entry, requisite to complete the exhibit, is omitted this year for lack of time for its preparation.

## APPENDIX NO. 3.

*Information furnished to Departments of the Government in reply to special requests, and to individuals upon application,\* during the fiscal year ending June 30, 1885.*

Date.	Name.	Data furnished.
1884.		
July 2	John Tatlock, Jr., Assistant Astronomer, Madison, Wis..	Six geographical positions determined by Coast and Geodetic Survey at Beloit, Wis.
12	Randolph Keim, Washington, D. C.....	Distance and direction of Sugarloaf Mountain, Md., from the Washington Monument.
15	Chief of Engineers, U. S. A.....	On the tides at Galveston, Tex.
17	Lieut. P. H. Ray, U. S. A., Signal Service.....	Copy of report on the discussion of his tidal observations at Ooglaamie, near Point Barrow, Alaska.
17	Director U. S. Geological Survey.....	Geographical positions in Northwest Georgia and Northeast Alabama and heights; also positions of two astronomical stations in Kentucky, with descriptions.
19	Director U. S. Geological Survey.....	Geographical positions of a number of points near the boundaries of Ohio, West Virginia, and Kentucky.
21	General V. D. Groner, General, Agent Merchants' and Miners' Transportation Company, Norfolk, Va.	Topography sea-coast of Virginia from life-saving station "Seatack" to life-saving station "Dam Neck Mills," 1859.
25	Horace S. Crowell, Boston, Mass.....	Topographical Survey West Island and vicinity, Buzzard's Bay, Mass., 1845.
25	Director U. S. Geological Survey.....	Geographical positions near western boundary of Massachusetts, and of State House, Boston.
28	Director U. S. Geological Survey.....	Geographical positions of fourteen stations in Northwest Georgia and Northeast Alabama.
29	Director U. S. Geological Survey.....	Geographical positions of three stations in California.
31	Maj. G. L. Gillespie, Engineer Corps, U. S. A.....	Bench-marks at Sandy Hook, N. J., for survey for deepening Gedney's Channel.
Aug. 5	Rudolph Hering, Assistant Engineer, Philadelphia Water Department.	Geographical positions, and geodetic and magnetic data for three triangulation stations.
6	Director U. S. Geological Survey.....	Positions of astronomical stations in Missouri and Kansas, with descriptions.
6	Maj. G. L. Gillespie, Engineer Corps, U. S. A.....	Geographical positions on lower New York Bay and vicinity.
6	P. B. Wood, Surveyor, Peshtigo, Wis.....	Geographical positions of stations in the vicinity of Peshtigo and data for secular change of the declination.
7	Maj. G. L. Gillespie, Engineer Corps, U. S. A.....	Bench-marks around Raritan Bay, especially at Locust Grove Gravesend Bay.
12	E. S. Holden, Director Astronomical Observatory, Madison, Wis.	Result for latitude of Coast Survey Station Madison from revised star places.
15	Harbor Commission of Norfolk and Portsmouth.....	Part of East Branch Elizabeth River, Va., 1873 and 1882.
22	Prof. A. Hall, U. S. Naval Observatory.....	Declination of nine stars used for determination of latitude.
26	Prof. J. Howard Gore, Columbian University.....	Information respecting certain statistics of, and recent progress in, geodesy on the Coast and Geodetic Survey.
27	E. G. Butler, Henderson, Vance County, North Carolina..	Variation in the magnetic declination at Henderson between 1800 and 1885.
28	Jacob W. Rand, Surveyor, Vanceburg, Ky.....	Information respecting magnetic declination at that place.
30	O. F. Horner, New Egypt, N. J.....	Results of magnetic investigations.
Sept. 6	W. S. Summers, Charleston, W. Va.....	Latitude and longitude of astronomical station at Charleston.
6	General William Birney, Washington, D. C.....	Copy of survey of Ashepoo River near mouth of Mosquito Creek, S. C.

\*Tracings from topographic or hydrographic sheets, transcripts of unpublished results of the work, and other data, when supplied for private use, are furnished upon payment of the cost of preparation in the office.

## APPENDIX No. 3—Continued.

Date.	Name.	Data furnished.
1884.		
Sept. 12	Capt. F. A. Hinman, Engineer Corps.....	Hydrographic survey of South Branch, Elizabeth River, Va.
13	D. B. Wellman, Assistant U. S. Engineer, Saint Louis, Mo.	Geodetic data of six trigonometrical stations on the Missouri River.
15	H. A. Wise, Superintendent Public Instruction, Baltimore	Table of magnetic declination at Baltimore 1810 to 1885 and information of position of agonic line at present and in former centuries.
16	M. A. Miller, Engineer, Oceana, Wyoming County, W. Va.	Rate of change of magnetic declination in West Virginia and position of agonic line at present.
17	International Electric Exhibition, Philadelphia, Prof. Snyder.	Determination of the magnetic dip, horizontal and total intensity at the test laboratory of the exhibition.
18	James L. Bryan, Secretary of Board of School Commissioners, Cambridge, Md.	Information about secular variation of the magnetic declination at Cambridge, Md., and declination at present.
18	Maj. C. W. Raymond, Engineer Corps, U. S. A.....	Geodetic data about Providence, Cape Cod; position of twenty trigonometrical points.
22	Maj. G. L. Gillespie, Engineer Corps, U. S. A.....	Hydrographic survey of eastern part of Hempstead Bay, L. I., New York, 1880.
Oct. 1	E. D. Ficklin, Fairfax Court House, Va.....	Magnetic declination at Fairfax since 1820.
2	D. C. Sanford, South Norwalk, Conn.....	Magnetic declination off Westport, Conn.
3	Emil Mayer, Munich, Germany.....	Compiled tracing of Mississippi River Delta and adjacent coast, together with unfinished proof of Coast Chart No. 94, 1-80000.
7	Thomas D. Davis, Lynchburg, Va.....	Geographical position of Lynchburg.
11	Maj. C. W. Raymond, Engineer Corps, U. S. A.....	Comparative map of the extremity of Cape Cod, Massachusetts, from the surveys of 1848 and 1857, and Commissioner's survey of 1867.
11	S. G. Hilborn, U. S. District Attorney, San Francisco, Cal.	Topographic and hydrographic surveys of Mare Island and Napa Creek, and adjacent marsh lands.
18	Maj. S. M. Mansfield, Engineer Corps, U. S. A., Galveston, Tex.	Unfinished proof of Coast Chart No. 110, Corpus Christi Bay.
14	Director U. S. Geological Survey, Washington, D. C.....	Height above the sea of one hundred and twenty geographical positions in Massachusetts.
22	G. H. Cook, State Geologist, New Jersey.....	Geodetic data of twenty-two trigonometrical points in New Jersey.
29	Capt. William T. Russell, Engineer Corps, U. S. A.....	Bench-marks at Tampa, Cedar Keys, Apalachicola Bay, and Key West.
30	A. M. Ford, Atlantic City, N. J.....	About Tide Tables and the tides at Sandy Hook and Fernandina.
30	Editor of Science, Cambridge, Mass.....	Records of self-registering tide-gauges at Sancelito, Cal., Kodiak, Alaska, and Honolulu.
Nov. 4	Director U. S. Geological Survey, Washington, D. C.....	Geographical positions in Kentucky near the boundary of West Virginia and Ohio.
5	A. Foster Higgins, chairman of the Standing Committee of Harbor and Shipping, New York Chamber of Commerce.	Hydrographic survey of entrance to New York Harbor made in 1835, 1-10000.
6	Prof. S. H. Pritchett, Saint Louis University.....	Telegraphic longitude of Saint Louis as determined in 1870 and 1881.
6	J. P. Bogart, Engineer of the Connecticut Shellfish Commission.	Geographical position of Milford spire.
7	Director U. S. Geological Survey, Washington, D. C.....	Angles to Standing Indian, N. C., from Rabun and Blood stations.
7	Richard Lamb, Norfolk, Va.....	Information about methods for finding the true meridian with reference to magnetic meridian.
10	Capt. F. V. Greene, Assistant Engineer Commissioner, District of Columbia.	Statistics of a number of primary, secondary, and tertiary triangulation stations in and around the District.
12	J. P. Bogart, Engineer Connecticut Shellfish Commission..	Topographical survey of west shore of New Haven Harbor, vicinity of Savin Rock, and Oyster River Point, 1872.
12	William F. Smith.....	Relating to loan of tide-gauges for use in Delaware Bay.
12	G. L. Vose, Boston Institute of Technology.....	Azimuth of line Blue Hill to Boston State House.
14	A. Foster Higgins, chairman of the Standing Committee of Harbor and Shipping, New York Chamber of Commerce.	Diagram showing the progressive and retrograde changes of Sandy Hook Spit; also cross-section of main ship-channel to Flynn's Knoll.
17	Mr. E. S. Philbrick, C. E., Boston, Mass.....	Hydrographic survey of Pocasset and Red Brook Harbors, Buzzard's Bay, Massachusetts.
20	M. A. Miller, C. E., Staunton, Va.....	Geographical position of Ivy Station, West Virginia, and magnetic declinations in West Virginia.
21	Prof. C. F. Osborne, Cornell University, Ithaca, N. Y.....	Matters relating to the building of magnetic observatories.
24	Lieut. M. M. Macomb, U. S. A., Fort Monroe, Virginia.....	Distance and direction from Old Point Comfort Light to Thimble Shoal Light.
24	Capt. H. S. Taber, Engineer Corps, U. S. A., Little Rock, Ark.	Geographical position of Little Rock.
25	General John Westcott, President Florida Canal Company.	Hydrographic survey Florida Passage, Jupiter Narrows to Jupiter Inlet.

## APPENDIX No. 3—Continued.

Date.	Name.	Data furnished.
1884.		
Dec. 3	A. J. Hill, Saint Paul, Minn. ....	Length of a degree of the meridian in latitudes 48° to 49°; geographical position of Minneapolis, Minn., and information respecting local deflection of the plumb-line in the Eastern States.
6	H. F. Walling, U. S. Geological Survey .....	Seven geodetic positions near southwest corner of Massachusetts.
6	Lewis Pittman, Clearville, Pa. ....	Secular variation of magnetic declination at Clearville between 1780 and 1885, with diagram.
9	F. M. Drew, Attorney-at-Law, Lewiston, Me. ....	Change in the direction of the magnetic needle at Leeds, Maine, between 1809 and 1884.
10	E. H. Roberts, Utica Morning Herald and Gazette, Utica, N. Y. ....	Geographical data respecting the position of New York Bay.
10	James Moylan, Engineer Atlantic and Pacific Railroad, Peach Springs, Ariz. ....	Geographical position of six places in New Mexico, Arizona, and California.
11	Director U. S. Geological Survey .....	Geographical and geodetic information respecting stations in the vicinity of southwest corner of Massachusetts.
13	Lieut. Fred. V. Abbot, Engineer Corps, U. S. A. ....	Geodetic data, descriptions of stations, and sketch of triangulation vicinity of Fernandina, Fla., Saint Mary's, Ga., and Tiger Island, Fla.
15	Director U. S. Geological Survey .....	Geodetic positions in the vicinity of Front Royal and Strasburg, Va.
17	U. S. Light-House Board .....	Hydrographic survey L'Homme Dieu Shoal, Nantucket Sound.
17	.....do.....	Hydrographic examination of shoal ground off Point Judith.
18	Prof. Fairman Rogers .....	Hydrographic survey part of Cumberland Sound, Georgia.
22	F. K. Hazen, Goffstown, N. H. ....	Geographical positions of Manchester and Unkenonuc.
23	Hon. E. Moody Boynton, Newburyport, Mass. ....	Hydrographic survey of Sabine and Calcasieu Passes and coast line between the same, with a map of Louisiana.
27	G. L. Vose, Institute of Technology, Boston, Mass. ....	Height of trigonometrical station at Blue Hill, Mass.
27	Fauth & Co., mathematical-instrument makers, Washington. ....	Computation of length of four standard base bars.
1885.		
Jan. 8	H. F. Walling, U. S. Geological Survey .....	Logarithmic ratio of Borden's linear measure to meter, and geographical position of Greylock and Saddle Mountains, Massachusetts.
9	Director U. S. Geological Survey .....	Geographical positions and geodetic results of triangulation in Southern Tennessee, 1884 work.
9	Director U. S. Geological Survey .....	Position of station Buffalo, Virginia, and description.
15	James P. Bogart, Engineer Connecticut Shellfish Commission. ....	Hydrographic survey of Townsend's Ledge, off New Haven, 1872.
16	George H. Cook, State Geologist, New Jersey. ....	Geographical positions coast of New Jersey, between Goshen Creek and West Creek, and between Townsend's Inlet and Absecon Light.
16	J. P. Winthringham, New York .....	Magnetic horizontal intensity at New York in dynes.
19	Prof. Henry Mitchell, Boston, Mass., for friend .....	Mean high and low waters and bench-marks at Boston navy-yard.
22	Albert Baylea, U. S. Engineer's Office .....	Bench-marks and tides at South Island, Winyah Bay, S. C.
22	T. J. Henderson, Commissioner of Agriculture, Georgia. ....	Geographical positions of five hundred and five points in Georgia.
22	Van Antwerp, Bragg & Co., Cincinnati, Ohio .....	Geographical positions of Little Rock and Helena, Ark., and of Kansas City and Saint Louis, Mo., and Fort Smith, Ark.
23	Capt. Charles F. Powell, U. S. Engineers, Portland, Oreg. ....	Bench-marks and tides in Budd's Inlet, Puget Sound, Washington Territory.
24	H. F. Walling, U. S. Geological Survey .....	Description of two stations near the southwest corner of Massachusetts.
Feb. 2	C. G. Rupert, Yale College, New Haven, Conn. ....	Information on geodesy.
2	J. T. Kille, Upper Tract, Pendleton County, W. Va. ....	Information on distribution of magnetic declination in the United States.
3	L. Cutshaw, Denver, Colo. ....	Determination of astronomical azimuth.
4	G. de Weckherlin, Minister Plenipotentiary of the Netherlands. ....	Copy of earthquake waves as recorded on the self-registering tide-gauges at San Francisco, Alaska, and Sandwich Islands.
5	A. W. Parker, Brooklyn, N. Y. ....	Limits of marsh land in Hampstead and South Oyster Bays, Long Island, 1880.
7	Dr. Henry J. Bigelow, 52 Beacon street, Boston, Mass. ....	Topographic survey western part of Nantucket Island; vicinity of Tucker's Island, Massachusetts.
7	Charles Hervey Townshend, New Haven, Conn. ....	Sketch showing limits of resurvey of Long Island Sound, New York; also tides and tidal observations in New Haven Harbor.
7	Topographer Post-Office Department .....	List of geographical positions in the States of New York, Vermont, California, and Nevada.
2	David Porter, Custom-house, Savannah, Ga. ....	Relating to the diurnal inequality in time, as given in the tide-tables for 1885.

## APPENDIX No. 3—Continued.

Date.	Name.	Data furnished.
1885.		
Feb. 12	S. Huston, Richmond, Ohio.....	Tables and charts of distribution of magnetic declination in the United States.
13	D. A. Nash, Office Commissioners of Pilots, New York...	Magnetic disturbed regions; vicinity of Long Island, and effect on compasses on board ship.
17	M. L. Baxter, Derby Line, Vermont.....	Geographical position of Boundary station near Derby, and of Jay Rock, Vt.
19	J. E. Laidler, Hawkinsville, Ga.....	Magnetic declination at Hawkinsville at present.
24	F. C. Purdy, Skokomish, Mason County, W. T.....	Instructions for magnetic observations and chart of distribution of the magnetic declination in 1885.
24	G. R. Prowell, York, Pa.....	Three geographical positions determined by the survey in York County.
27	W. H. Holmes, Philadelphia, Pa.....	Table of geographical positions in the city of Philadelphia.
Mar. 2	William Fears, Town Point, Cecil County, Md.....	Topographic and hydrographic survey of Mill Creek, Piankatank River, Virginia, 1860.
5	F. H. Quin, Assistant Engineer, Chesapeake and Ohio Railroad, Richmond, Va.	Magnetic declination at Richmond between 1750 and 1885.
13	M. W. Raneona.....	Publications of the Coast and Geodetic Survey on Terrestrial Magnetism.
13	H. H. Moses, Superintendent Sewers, City Hall, Boston, Mass.	Height of tides at Boston on February 9 and 10, 1867.
16	H. F. Payson, City Engineer's Office, Providence, R. I. .	Explanation of time used in the Tide Tables for 1885.
17	Alfred P. Boller, C. E.....	Topographic and hydrographic survey of Arthur Kill and Staten Isl and Sound.
18	United States Light-House Board.....	Wreck chart, San Francisco and approaches, 1-200000.
19	C. H. Farley, Harbor Commissioner, Portland, Me.....	Hydrographic survey of Fore River, Portland Harbor, Maine.
23	R. Hering, Philadelphia Water Department.....	Geographical position of station Topton and description of station.
23	O. J. Klotz, President Association of Dominion Land Surveyors.	Copies of three of the latest pamphlets on Magnetic Declination—Dip and Intensity—1881 and 1882.
23	D. Koppmann, Engineer Harbor and Land Commissioner's Office, Gloucester, Mass.	Seven geographical positions on Gloucester Harbor and descriptions of stations.
25	M. Williams, Collector's Office, Stonington, Conn.....	Position of the magnetic pole at present.
25	Capt. George H. Cook, Assistant Quartermaster, U. S. A.	Hydrographic survey of New Rochelle Harbor and vicinity, Long Isl and Sound, 1883.
27	J. T. Gardiner, Director New York State Survey.....	Ninety-two geodetic positions in counties in the vicinity and north of New York City.
28	W. L. Nicholson, Topographer Post-Office Department..	Geographical positions in Missouri, Kansas, and Colorado.
30	Hoyt, Fogg & Donham, Portland, Me.....	Predicted tides for Boston and Portland for 1886—Jan., Feb., Mar.—for Maine State Year Book.
31	Director U. S. Geological Survey.....	Geodetic positions in Southeastern Massachusetts, determined in 1884.
Apr. 4	J. P. Bogart, Engineer Connecticut Shellfish Commission..	Geographical positions of three stations Harbor of New Haven, Conn.
7	J. P. Bogart, Engineer Connecticut Shellfish Commission..	Distances and azimuths between three trigonometrical stations.
7	William Smith, Deputy Minister of Marine, Ottawa, Canada.	Appendix No. 8, Report of 1876; also, a paper on "A Tide-gauge with Heating Apparatus," and a paper on observing currents.
8	Silas Weeks, New Orleans, La.....	Topographic survey north shore Biloxi Bay, Mississippi Sound.
13	L. M. Wright, Civil Engineer, Troy, N. Y.....	Secular variation of the magnetic declination at Troy, 1817 to 1885.
15	H. T. Greenleaf, C. E., Elizabeth City, N. C.....	Secular change on Virginia and North Carolina boundary line of magnetic declination between 1728 and 1885.
15	Director of U. S. Geological Survey.....	Geographical positions and descriptions of astronomical stations in Washington Territory and Oregon.
16	Maj. Charles W. Raymond, Engineer Corps, U. S. A.....	Hydrographic survey mouth and bar of the Merrimac River, Massachusetts, 1851.
16	United States Light-House Board.....	Hydrographic survey Anclote Bay, West Florida, 1884.
23	J. T. Gardiner, Director New York State Survey.....	Descriptions of seventy-eight positions in Southern New York.
24	J. H. Mansy, Rockingham County, Virginia.....	Data for re-running at present an old magnetic line.
25	E. Deville, Surveyor-General, Dominion of Canada.....	Longitude of astronomical station Seattle, Washington Territory, and description of station.
25	Director of U. S. Geological Survey.....	Abstract of horizontal directions of eight primary triangulation stations in Virginia and West Virginia.
May 1	Surgeon-General's Office.....	Times of high-waters at Chain Bridge, on the Potomac, on May 2, 1885.
2	Lieut. G. L. Anderson, U. S. A., Philadelphia.....	Instructions for making magnetic observations.
2	E. M. Scofield, Schenectady, N. Y.....	Pamphlet and chart of magnetic declination for 1885.
2	T. W. Barally, Schenectady, N. Y.....	Pamphlet and chart of magnetic declination for 1885.
6	A. W. Phillips, Yale College, New Haven, Conn.....	Pamphlet on distribution and secular change of magnetic declination, and directions for making magnetic observations.

## APPENDIX No. 3—Continued.

Date.	Name.	Data furnished.
1885.		
May 15	Director U. S. Geological Survey .....	Height of bench-marks and descriptions of stations, spirit-level line from Hagerstown, Md., to Alexandria, Va.
16	Henry Seykes, New Haven, Conn .....	Length of Connecticut River in the States of New Hampshire, Massachusetts, and Connecticut.
19	Postmaster, Harrisonville, Mo .....	Geographical position of Harrisonville.
20	William C. Gunnell, Hampton, Va .....	Height of bench-mark of spirit-levels at Hampton, Va., above mean low water.
21	R. Keith, Washington, D. C .....	Prediction of tides for Philadelphia for 1886, for Ledger Almanac.
22	Director U. S. Geological Survey .....	Height above the sea of eight trigonometrical stations in West Virginia.
23	A. M. Ford, Salem, N. J .....	Predictions for Atlantic Coast for 1886. Java earthquake waves.
25	G. L. Osborne, President State Normal School, Warrensburg, Mo.	Geographical position and height of the Normal School.
26	J. P. Little, Fernandina, Fla .....	Magnetic declination at Fernandina in 1831 and 1885 and annual change.
June 1	H. D. Cooke, Washington, D. C .....	Hydrography of inside passage between Saint Augustine and Mala Compra Creek, Florida.
1	J. Francis Le Baron, C. E., Jacksonville, Fla .....	Hydrography west coast of Florida, Rocky Point to Long Boat Inlet, with unfinished proof, Coast Chart No. 76, 1-80000.
1	G. H. Millman, Fort Meade, Polk County, Fla .....	Magnetic variation in Florida.
2	Alfred Higbie, San Francisco, Cal .....	Distribution of magnetic declination in the United States and secular variation of the declination.
2	Clement Manley, New Berne, N. C .....	Table of decimal values of the magnetic declination at New Berne since 1870.
3	Charles E. Paine, C. E., Providence, R. I .....	Arrangement for testing compasses and laying out a meridional line.
3	City Engineer, Providence, R. I .....	About the self-registering tide-gauge loaned by the Coast Survey to the city of Providence.
3	Officer in Charge U. S. Engineer's office, Philadelphia, Pa.	About the self-registering tide-gauge at Fort Mifflin, belonging to the Coast Survey.
4	S. D. Caldwell, Shade Gap, Huntington County, Pa .....	Three pamphlets from Coast and Geodetic Survey reports, bearing on the magnetic declination, especially in Pennsylvania.
6	Director U. S. Geological Survey .....	Five principal geographical positions and descriptions of stations in Missouri.
6	George Foeberry Lyster, Engineer, Liverpool, England. By request of James B. Eads, and for use in British Parliament.	General tidal curves for Governor's Island and Sandy Hook.
8	George Foeberry Lyster, Engineer, Liverpool, England.	Diagrams of tides, for long series, at Sandy Hook and Governor's Island, N. Y.
10	L. N. Christensen, Surveyor, Sand Hill, Marshall County, W. Va.	Magnetic declination at Wheeling.
10	Prof. George H. Cook, State Geologist of New Jersey, New Brunswick, N. J.	Tidal bench-marks in and around Philadelphia, and matters connected therewith.
13	Samuel M. Gray, C. E., Providence, R. I .....	Letter relating to observations of tides for 1878 to 1880.
16	Director U. S. Geological Survey .....	Geographical positions in the vicinity of the Yolo Base, Cal., and geographical position of Austin, Tex.
19	G. T. Wyer, Wellfleet, Mass .....	Magnetic declination at Wellfleet.
20	F. Leonard, Pine Grove, Coxsackie, Greene County, N. Y.	Magnetic publications of the Coast and Geodetic Survey.
22	C. A. McLeod, McGill Meteorological Observatory, Montreal, Canada.	Position of trigonometrical station on Mount Royal and of Cambridge Observatory.
23	H. M. Robert, Lieutenant-Colonel Engineers, U. S. A .....	Geodetic positions vicinity of Marcus Hook, Delaware.
23	U. S. Land Office .....	Shore line information, vicinity Mississippi Delta.
26	C. A. McLeod, McGill College Observatory, Montreal, Canada.	Longitude of Chicago and Detroit and memoranda of references to Canadian longitudes.
26	Maj. C. W. Raymond, Engineer Corps, U. S. A .....	Geographical positions in Boston Harbor.
26	Director U. S. Geological Survey .....	Descriptions of ten principal triangulation stations in the vicinity of Sacramento, Cal.
26	Prof. George H. Cook, State Geologist of New Jersey, New Brunswick, N. J.	Relating to tidal bench-marks around New Jersey. Descriptions of some furnished.
29	Dwight Porter, Canton Center, Conn .....	Height of mean high-water above mean sea-level in Boston Harbor.
29	City Clerk of Calais, Me .....	Topographic survey of Calais, Me., 1869.
29	W. H. Chadbourn, Jr., Wilmington, N. C .....	Magnetic declination in Columbus County, North Carolina.
29	O. H. Tripp, Rockland, Me .....	Results of magnetic observations of the Coast and Geodetic Survey in Maine.
29	W. C. Holbrook, County Surveyor, Coleta, Ill .....	Table of azimuth and time of elongation of Polaris and distribution of magnetic declination in Illinois.
30	D. Koppmann, Engineer Harbor and Land Commissioner's Office, Massachusetts.	Positions of stations Rallent and Beacon Hill and distance and azimuth between them.



## APPENDIX No. 4.

REPORT OF THE ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR THE YEAR ENDING  
JUNE 30, 1885.

U. S. COAST AND GEODETIC SURVEY OFFICE,  
Washington, D. C., June 30, 1885.

SIR: I have the honor to submit herewith my annual report from the Office, with the usual annual reports from each Division.

As in former years, the Computing Division, under the able management of Assistant C. A. Schott, has fully maintained its efficiency, all computations having been kept up to date, and a number of valuable reports submitted.

All calls for information have been promptly met, especially the unusually large number from the Office of the Geological Survey, and this notwithstanding the loss, by resignation, of Dr. J. G. Porter, one of the ablest computers, in September of last year, and the detachment of another computer for a considerable portion of the year. Mr. Schott has also found time to add still another mass of magnetic data to that already published, in the new tables of magnetic dips and intensities comprising some two thousand results, with a discussion of the secular variation and geographical distribution of these elements in the United States.

It is creditable to the growth and scientific development of the country that this class of information is more eagerly sought for than any other, despite its somewhat recondite character.

The Engraving, Electrotyping, and Printing Divisions have remained in charge of Assistant H. G. Ogden. The work of engraving new charts has, as during last year, given way to the more pressing necessity of making corrections to charts already published and largely used in navigation, where resurveys have developed important changes. Four hundred and twenty-one plates have been thus corrected.

Assistant Ogden urges an increase in the number of new charts to be printed and published by photolithography, that the results of our field surveys may be more promptly made available for public use. You are aware that this method has been pushed to the extreme limit possible with the present force in our Drawing Division.

The increase has been so rapid in excellence and in artistic merit in map-printing by this method that I have been disposed to submit to you a plan for a small addition to our force of draughtsmen, with a corresponding reduction elsewhere, in order to enable the Office to dispose more readily of the accumulating mass of data now on hand and continually coming in. A comparison of the newly published charts of New London Harbor and the Thames River, and also that of Newport, R. I., with other charts printed by photolithography two years ago will show the great change for the better to which I refer. The great diminution of cost is another reason for increasing this department of our work.

Improvements have been made in the batteries used in electrotyping, and a greater amount of work of a better character has been the result. These improvements have shown that it is not best to substitute a dynamo for the Smee and Walker batteries. A more uniform and regular deposit of copper has been obtained by the improved batteries upon the very large surfaces of our engraved plates than was had by the action of a dynamo.

The Printing Office has been rebuilt according to the original design, giving the printers more



desirable quarters, with greater light and better air, while new presses of better quality have also been added. Much difficulty has been experienced since January last in keeping up our supply of paper of the proper quality and size. This, joined to the delay occasioned by putting up the new building, has rendered the whole number of charts printed during the year less than in the previous year. Arrangements have been concluded by which it is probable that a larger number will be produced and disposed of in future.

Mr. Ogden calls special attention to the able services of Mr. J. H. Smoot, Clerk of the Engraving Division.

The Tidal Division has remained in charge of Mr. R. S. Avery. It is hoped that the work in this division will be largely increased in efficiency during the ensuing year. The Tide Tables for the Atlantic and Pacific Coasts for 1886 are in the hands of the printer. In their preparation the "Tide Predictor," invented by Professor Ferrel, has been largely used.

An interesting incident of the year in this division has been the receipt from three widely separated tidal stations in the Pacific Ocean of the automatic records of the perturbations occasioned by the great Krakatoa earthquake of August 26, to September 2, 1883.

At the self-registering tide-gauges near San Francisco, Kadiak in Alaska, and Honolulu in the Sandwich Islands, the earthquake waves are sharply and distinctly recorded. This is especially the case at Honolulu. Photographic copies of the original records prepared in the Office have been forwarded to the Krakatoa Committee of the Royal Society at London by their request, and have also been printed in "Science" in this country. It is unfortunate that the self-registering tide-gauge, formerly maintained by the Coast and Geodetic Survey at Mazatlan, had been destroyed in one of the frequent attempts at revolution in that region. A similar automatic record of that place would have been of the highest service in estimating the time and force of this great earthquake wave in its progress over a space equal to more than one-third of the distance around the earth.

The Drawing Division has been actively employed during the entire year. In addition to its regular work, as set forth by Mr. Bright, it has furnished a large number of maps and tracings, specially called for by different branches of the Government and by private parties. Many of these have been of an elaborate character, requiring much time in their preparation.

In Appendix No. 3 is given a tabular statement of information furnished from this and other divisions of the Office in reply to official and unofficial requests.

A new feature introduced during the year has been the preparation of original topographic sheets for photolithographic printing in fac-simile. This has been very successful, the reproduced sheets showing great clearness in outline, with little or no distortion in scale. A combination of topographic and hydrographic original sheets upon a part of the Pacific Coast has also been tried at the instance of Assistant Davidson, and bids fair to be successful.

A re-organization of this Division, with a small addition to its force, as before suggested, will add largely to its efficiency.

Mr. M. W. Wines, General Office Assistant, has had charge of the Miscellaneous Division, and of all supplies to field parties of every kind of material needed by them, except instruments, as also of the distribution and sale of the publications of the survey. By his methodical manner of conducting these duties every field party has been promptly supplied, and much valuable time saved. His services to the Office in its relations with the Government Printing Office have contributed largely to the prompt publication of the Annual Reports.

The Office buildings, the Carpenter Shop, and the Map-mounting and Chart rooms have also been under his direction, as has been all communication with the Government Printing Office, and general supervision of all printing for the Coast and Geodetic Survey executed there. His duties have been laborious and responsible, and I owe him thanks for the thoroughness with which they have been attended to.

In the Instrument Division, under charge of Mr. G. N. Saegmuller, Chief Mechanician, much work has been done in repairs and remodeling of many instruments. Many old instruments have been regraduated and otherwise improved, and a large amount of miscellaneous work done. The addition made to the printing office involved the removal of the small testing observatory west of it, and a new and better one adjoining the Office of the Chief Mechanician has been erected in its place.

New instruments have been purchased as needed. All the apparatus which could be spared from use, including representative instruments in every department of our work, was put in thorough order during October and November, and sent to the New Orleans Exposition, in charge of Dr. J. J. Clark, adjuster in the Office of Construction of Standard Weights and Measures.

Improvements in this division are now planned and in process of execution which will give increased facilities and enable each person employed to do more work with greater ease to himself than has been heretofore possible, and the work-shops will then be more independent of outside aid. In these improvements I have had the skillful and ingenious assistance of Mr. Saegmuller.

A tabular statement will be found among the appendices to this report, giving in detail all information as to the number and classes of records added to the archives during the past year. The whole number of new volumes of records of observations, original and duplicate, is 1228. Up to March 31st the archives were in charge of Mr. R. M. Harvey.

At the close of the last fiscal year new projection tables, based upon the Clarke spheroid, and extending from the Equator to the Pole, were in course of preparation under my direction. These were completed and have now been printed, forming a book of 188 quarto pages, and being the most thorough and complete compilation ever printed upon this subject. While not free from error, it is hoped that these tables will prove to be more free from tabular errors than others before published. I am under obligations for faithful labor in this work to Sub-Assistants Baylor and McGrath, and to Mr. F. Morse, aid, who made the computations, and to Mr. McGrath and Miss S. C. Ayres, who prepared the tables for the printer, and read the proof. In this last most important matter I have also to acknowledge the great assistance rendered in the computing division by Assistant Schott and Mr. Doolittle, which added largely to the accuracy of the completed work.

The work of compilation of a map of the United States has made slow progress during the past year for lack of competent persons to continue it who could be spared from more pressing duties. But a large stock of material to be used in the work has been collected and brought to the office, ready for use as soon as opportunity offers.

At the commencement of the fiscal year, a measurement of all salt and fresh marsh land upon the Atlantic and Gulf Coasts had been undertaken at the request of the Commissioner of Agriculture. This was completed by Mr. A. Lindenkohl and Mr. McGrath, and the results communicated in tabular form. They have since been printed. The work was elaborate and laborious, occupying about three months.

After the middle of August, just as I hoped, with your permission to have a month of field-work, my principal Assistant, Mr. Henry W. Blair, was seized with typhoid fever and taken to Providence Hospital. His illness was very severe and lasted nearly three months. When able to leave the Hospital he went to his home in Lexington, Va., to complete his recovery, and there wrote a pamphlet giving a description of the principal instruments contained in the Coast and Geodetic Survey Exhibit at New Orleans, which was printed and circulated there. Having apparently recovered he started for New Orleans to take charge of the arrangement of the Exhibit and its display in the Government Building. But his recovery was not real, and on his way he was suddenly again prostrated, and died at Nashville of peritonitis on the 15th of December.\*

Assistant Henry Wayne Blair was appointed upon the Coast Survey at my instance, as an aid in January, 1871. He was a graduate of the Virginia Military Institute, where his father, Col. William B. Blair, was a Professor. He was the first young gentleman from the South appointed upon the Survey after the war, being strongly recommended by General F. H. Smith, Superintendent of the Virginia Military Institute, and by General Henry C. Wayne and General Joseph E. Johnston, of Georgia. He was attached to my party, then in Georgia, and remained with me until 1877.

Of all the young men whom it has been my good fortune to train to become useful and efficient officers upon our work, no one has excelled him and but one has been his equal. Prompt, zealous, and untiring in field duty, he was equally useful in the Office, where his excellence as a close observer and mathematical reasoner procured him rapid promotion.

In 1875, at a competitive examination of twenty-three Aids, chosen from all the scientific institutions of the country, he came out at the head of the list.

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\* A tribute to the memory of Mr. Blair appears in Appendix No. 18.

In all those traits of personal character which cause a man to be loved, respected, and honored among his comrades who best knew him, no one held a higher position, and no one is to-day more lamented.

To me, both personally and officially, his loss is irreparable. I loved him as a son, and leaned upon him as my Chief Assistant in the Office, to an extent I did not realize until his untimely death.

Assistant C. H. Sinclair was temporarily assigned by you to take Mr. Blair's place in the Office, and later Sub-Assistant F. H. Parsons was permanently assigned, and remained on duty with me until relieved, to return to field duty, being succeeded by Assistant B. A. Colonna. Mr. Parsons has been faithful and assiduous in the discharge of his duties, and I owe him thanks therefor.

During the year a larger number of plates than usual have been electrotyped for the Engineer Office of the Army and the Hydrographic Office of the Navy. Under an arrangement with these Offices, made by my predecessor, this work has been paid for at a fixed rate, and the Office has received from this source the sum of \$1,991.42, which has been turned over by me to the Disbursing Office, and placed to the credit of our appropriation for electrotyping, &c. (See Sundry civil bill, 1884-'85; appropriation for Coast and Geodetic Survey Office expenses, paragraph 2.)

On the 2d of this month, I received the usual monthly statement of expenditures and available balances, and found that after allowing for all probable expenditure under this item, for the remainder of the year, there would still remain an available balance of nearly \$3,000, enough to enable me to carry out certain much-needed improvements, which I had long contemplated, but had not means to undertake.

These were (1) an elevator to enable the bearers of our heavy copper plates to transport them readily between the printing office, near the basement of the building, and the engraving room in the upper story, and (2) a gas-engine of sufficient power to run the elevator, and also to supply power to the different work-shops—enabling more work to be done in all of them with less labor.

Having ascertained from the First Comptroller that the proposed expenditure was lawful, I proceeded, with your permission, to make the necessary contracts, and the work upon all of them is well in hand. When completed I feel sure that they will effect a great gain in both efficiency and comfort.

I have also fitted up a large room upon the lower floor of the Fire-proof building for a Library, which is now in a suitable place with plenty of light, and so near to the Archives that the keeper of the Archives can also act as Librarian.

The large space between the new Library and the Archives is to be fitted up with shelves for holding copper-plates. The rooms occupied by the old library are occupied for instruments, which are now near the instrument work-rooms, and easily accessible therefrom, while the room opposite, now filled with copper-plates, will be turned over to the Miscellaneous Division, which is in great need of more room for storage of heavy books that now overload the attic of the main building.

During the next six months I hope also to reorganize the Archives, and render the large and valuable mass of data collected there more accessible to all who have to consult our records.

The experience acquired in 1884 has enabled me to see opportunities for some retrenchment in the expenditures of the office, and last winter, with your consent, I reduced the estimates accordingly. The amount appropriated for office expenses during the fiscal year now beginning is \$40,800, while for the year ending to-day it has been \$44,600, thus effecting a saving of \$3,800. If other changes can be effected this sum may be still farther reduced in the next year.

The clerical duties of the office have been ably discharged by Dr. W. B. French, to whom I have been greatly indebted. He has taken entire charge of the accounts of the office, including the receipt and care for the funds received for sale of charts, amounting to \$3,920.84, which amount has been turned into the Treasury.

Yours respectfully,

C. O. BOUTELLE,

*Assistant U. S. Coast and Geodetic Survey, in charge of Office.*

To the SUPERINTENDENT.

REPORT OF THE COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR  
ENDING JUNE 30, 1885.

## COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,

July 1, 1885.

DEAR SIR: In conformity with regulations, I herewith respectfully submit the usual annual report of work done by the several computers and others in this division of the office, for the fiscal year ending June 30, 1885.

The undersigned has continued in charge of the Computing Division, the personnel of which has with one exception remained as last year. The computing force sustained a serious loss by the resignation of Dr. J. G. Porter (now Director of the Cincinnati Observatory) soon after the beginning of the fiscal year. The place of this expert computer has not been filled. The Division was also deprived for nine months of the services of Mr. H. Farquhar, who was assigned to the party of Assistant C. S. Peirce.

This place was also left vacant during that time. The computing force being thus curtailed and having assigned to it the recomputation and adjustment to the Coast and Geodetic Survey triangulation of the Borden survey of Massachusetts, executed from 1832 to 1838, it became absolutely necessary to provide for some temporary assistance in order that the current work might be properly sustained. In consequence Mr. J. Nelson was assigned to the Computing Division from August 1, 1884, to September 20, 1884; Assistant O. H. Tittmann was assigned to it between September 16, 1884, and November 11; Assistant F. D. Granger reported for duty October 9, 1884, and was detached March 17, 1885; Mr. J. B. Boutelle reported for duty March 21, and continued to the close of the fiscal year; Mr. W. B. Fairfield reported for duty May 20, 1885, and left June 13, 1885; Mr. W. Auhagen was attached to the division during June, 1885. In consequence of the increased demand for professional information from field parties and for scientific and general information demanded in office correspondence, and in particular to satisfy calls from the United States Geological Survey, the services of Mr. E. A. Trescot as second clerk to the Division had to be retained throughout the year, and for nine days during June, 1885, Miss S. C. Ayres further assisted in copying records.

The Ooglaamie magnetic work, referred to in last year's report, was brought to a close soon after the beginning of the fiscal year, Sergeant (now Lieutenant) J. E. Maxfield being ordered on other duty July 12, 1884, and was seen through the press (forming 229 quarto pages) in May last. During this and the following month other heavy proof-reading (new edition of projection tables and new edition of table of factors for geodetic positions) was attended to. Special mention may be made of the following reports submitted by me:

On the results of the geodetic determination of the boundary lines of the District of Columbia; a discussion of the hypsometry of the Davidson quadrilaterals in central California; results of a new adjustment of all telegraphic longitudes, subject to geometrical conditions and determined by the Coast and Geodetic Survey; and an article entitled "The geodetic survey of the United States; its object and operations, considered from a theoretical and practical standpoint," with chart.

I have also completed a general collection of all magnetic dips and intensities determined in the United States from the earliest to the present time, arranged the material collected by States and Territories, and in each political division in the order of the latitudes of the stations and for each station, giving the separate results in chronological order. This work comprises nearly two thousand entries of dips and fifteen hundred entries of intensities. The discussion of the secular variation of the dip and of the horizontal and total intensities has been completed. I made also the usual annual determination of the magnetic elements at Washington on June 13 and 15, 1885.

The astronomical, geodetic, and magnetic records received at the office were examined for completeness of statements, and all data required in the office correspondence and referred to this division were promptly attended to.

A statement in detail of the work performed by each computer during the year is herewith appended.

Edward H. Courtenay attended to the preparation of geodetic data required by field parties

to the geographical registers and the keeping of the duplicate records, completed the adjustment of the secondary triangulation of Massachusetts, had charge of the recomputation and adjustment to the triangulation of the Coast and Geodetic Survey of the Borden triangulation of Massachusetts during the years from 1832 to 1838, a work which he completed with the assistance of the extra computers temporarily assigned to the division. The triangulation of this State is thus made quite complete, and the results of the whole based on the best data, or made uniform with the standard data now in use. This recomputation was undertaken chiefly in aid of the Geological Survey and for the mapping of topography.

Myrick H. Doolittle completed the computation of tertiary geographical positions on Lake Champlain in 1870, '71, '72; computed the geodetic connection of the astronomical station Strasburg, Va.; computed secondary positions in Alabama and on the Florida Reef near Cape Florida; based the coast triangulation north of Point Conception, California (executed in 1867, '69, '74, '78, '79), on the results of the primary triangulation; determined the heights of the main triangulation points in the vicinity and north of Santa Barbara Channel 1873, '74, '75 (Tittmann), and 1882, '83, '84 (Lawson); prepared the manuscript for second edition of table of factors for computing geographical positions on the Clarke spheroid of 1866; compiled a part of the annual geodetic statistics of the Survey; computed some tertiary geographical positions in Georgia, Pennsylvania, and New Jersey; adjusted the heights of trigonometrical stations between Lake Champlain and Lake Ontario, 1874 to 1884; made miscellaneous geodetic revisions; assisted in proof-reading, and in part recomputed the new projection tables, and reduced magnetic observations at Philadelphia, 1884, at Providence and Newport, R. I., 1884, and at four stations in Florida, 1883 and 1884.

Jermain G. Porter computed the following telegraphic differences of longitude: Saint Louis, Mo., and London, Ky., Saint Louis and Guthrie, Ky., Saint Louis and Henderson, Ky., Saint Louis and Little Rock, Ark., Saint Louis and Springfield, Ill., Kansas City, Mo., and Indianapolis, Ind., all of 1882 and secondary stations; computed the telegraphic differences of longitude, Louisville, Ky., and Charleston, W. Va., Louisville and Chicago, Ill., Louisville and Lexington, Ky., and Louisville and Louisa, Ky., all of 1883. Resigned August 30, 1884.

Alexander S. Christie completed the computation of the azimuth at Pioche, Nev., 1883; furnished mean places of stars for field parties, revised the latitude computations of Charlottesville, Va., Keeney, W. Va., Kansas City, Mo., and Eureka, Nev.; computed time and azimuth, station Keeney, W. Va., 1880; computed the telegraphic differences of longitude, Louisville and Greensburg, Ky., and Louisville and Jellico, Tenn., Louisville and Richmond, Ky., Louisville and Logansport, Ind., all of 1883; computed the difference of longitude, Washington, D. C., and Covington, Va., 1884; recomputed the latitude of Madison, Wis.; computed the heights of the line of spirit levels between Hagerstown, Md., and Alexandria, Va., 1883-'84, aided in proof-reading of new edition of projection tables and completed the reduction of spirit levels in the District of Columbia, 1884.

Charles H. Kummell completed the computation of the triangulation of Hood's Canal, Washington Territory, 1881, and of 1882-'84; revised measures of horizontal angles, triangulation of Connecticut, 1883, and of stations Tepusquet, Lospe, and Saddle Peak, Cal.; computed a number of tertiary positions in Florida, Louisiana, Georgia, Kentucky, Tennessee, and Massachusetts (Cape Cod and Boston Harbor); assisted me in the solution of a number of normal equations relating to magnetic computations; computed the supplementary triangulation of Philadelphia by Assistants McCorkle and Sinclair and Sub-Assistant Van Orden, 1885, and verified abstracts of angles, survey of New York.

Henry Farquhar completed the computation for latitude of Pioche, Nev.; computed the latitude of Charlottesville, Va., and of Cincinnati, Ohio, and commenced the computation for latitude of Gratiot's Grove, Wis., and Sherrill's Mound, Iowa. Was detached from the Computing Division, September 27, 1884, and re-assigned June 23, 1885, when he took up the last-mentioned computations.

Alexander Ziwet computed the geographical positions fixing the boundary of the District of Columbia; computed the position of points of the main series of triangles of the Hudson River; computed positions, survey of Long Island Sound and of the survey along the boundaries of New York, Connecticut, and Massachusetts; prepared abstract of angles coast stations California, near

Piedras Blancas, 1883; assisted Mr. Courtenay in the adjustment of secondary points in Massachusetts of the Coast Survey and of the Borden survey, and in bringing up the latter and other results of tertiary triangulation to the modern standard data of the Coast and Geodetic Survey; he also adjusted a number of secondary positions in New Hampshire, made miscellaneous geodetic revisions, and assisted me in establishing and solving certain normal equations in connection with magnetic dips.

P. R. Stansbury discharged the clerical duties of the Computing Division, being principally engaged in keeping up to date the geographical registers, copying reports, and marking out descriptions of stations for the copyist.

E. A. Trescot was engaged as copyist; furnished descriptions of stations and sketches, and completed certain duplicates of records.

Temporary assistance was given by the following-named persons:

J. Nelson from August 1 to September 20, 1884, was engaged on position computations under direction of Mr. Courtenay.

Assistant O. H. Tittmann from September 16 to November 11, 1884, computed magnetic observations made at Philadelphia; assisted in the revision of angles and adjustment of the secondary triangulation of Massachusetts, connecting the Coast Survey triangulation with that of Borden, executed about half a century ago.

Assistant F. D. Granger from October 9, 1884, to March 18, 1885, was engaged in revising and adjusting the Borden angles at 109 stations in Massachusetts, and in revising angles of the Coast Survey measured in Massachusetts and New Hampshire in connection with the Borden work. He computed also a number of geographical positions.

J. B. Boutelle from March 21, 1885, to the close of the fiscal year, assisted in the computations connected with the supplementary triangulation of Massachusetts made by Assistant G. Bradford, 1884, and with the older one of Borden, computing improved geographical positions; assisted me in proof-reading of the paper containing full record and my discussion of the magnetic work done at Ooglaamie, Alaska, 1881-'82-'83 (station in charge of Lieutenant Ray, U. S. A.).

During June Mr. Boutelle had also temporary charge of the archives (a duty disconnected from the Computing Division).

W. B. Fairfield from May 20 to June 13, 1885, was engaged in miscellaneous computations of positions.

W. Aubagen during June, 1885, was engaged in the computation of geographical positions under the direction of Mr. Courtenay.

S. C. Ayres June 20 to 30, 1885, attended to miscellaneous copying.

I remain, sir, yours, respectfully,

CHARLES A. SCHOTT,  
*Assistant in charge Computing Division.*

CHARLES O. BOUTELLE, Esq.,  
*Assistant in charge Office and Topography.*

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REPORT ON THE FIELD AND OFFICE WORK RELATING TO THE TIDES FOR THE YEAR ENDING  
JUNE 30, 1885.

COAST AND GEODETIC SURVEY OFFICE,  
August 28, 1885.

DEAR SIR: I respectfully submit this report on the work of the Tidal Division, of which I have been in charge during the year.

OBSERVATIONS.

Automatic tide-gauges, from which observations have been received or expected, have been used at the following stations:

Pulpit Harbor, North Haven, Me.; Providence, R. I.; New Haven Breakwater, Conn.; Governor's Island, N. Y.; Sandy Hook, N. J.; Fort Mifflin, near Philadelphia, Pa.; Charleston, S. C.;

Saucelito, Cal.; Saint Paul, Kadiak Island, Alaska; Fort Simpson, British Columbia; Honolulu, Sandwich Islands.

The gauges at Pulpit Harbor, Saucelito, and Saint Paul are kept running continually to obtain long unbroken series. The gauges near New Haven and at Governor's Island are run by hydrographic parties, and will be stopped during winter. The gauge at Sandy Hook does not work well in winter. It has not been doing good work for some months, and a better place should be found for it, where it can be run throughout the year.

Only a few observations have been received from Fort Mifflin, and those were not very good. A gauge should be used at Philadelphia by an experienced observer for at least a year, a good series there being much needed as a basis for predictions. Another automatic gauge will probably be established soon on the coast of Maine, in connection with the hydrographic work, the arrangements for which have been partly made. It has been found to add greatly to the value of hydrographic work to have it reduced by the aid of a good series of observations made with an automatic tide gauge, and where extensive surveys are in progress there should be at least one such gauge to serve as a basis for comparison with others.

The plan for obtaining a long series at Fernandina, or some place north of it on the Southern Coast, should be carried out, and the observations on the coasts of Louisiana and Texas, required for completing the tidal survey of the Gulf of Mexico, should be resumed and extended to a year at each place occupied. The range of the tides on these coasts is small, but their peculiar character gives them importance, as it is necessary to continue the observations day and night in order to get trustworthy data for reducing soundings, and this has not always been done.

In the following table I give a list of the stations at which automatic tide-gauges were in operation during the fiscal year, with names of observers and times of occupation of stations.

Section.	Name of station.	Name of observer.	Kind of gauge.	Permanent or temporary.	Time of occupation.		Total days.
					From—	To—	
I	Pulpit Harbor, Me.	J. G. Spaulding	2-roller	Permanent	April 27, 1884	April 30, 1885	370
I	Providence, R. I.	S. M. Gray	do	Temporary	January 1, 1878	December 31, 1880	900
II	New Haven, Conn.	L. B. Thompson	3-roller	do	July 31, 1884	June 1, 1885	173
II	Sandy Hook, N. J.	F. W. Shephard	2-roller	Permanent	July 1, 1884	September 1, 1884	63
	do	J. W. Corbett	do	do	March 31, 1885	April 30, 1885	31
II	Fort Mifflin, Pa.	U. S. Engineers	3-roller	Temporary	April 19, 1882	October 22, 1883	176
V	Charleston, S. C.	do	2-roller	do	January 1, 1885	March 28, 1885	70
X	Saucelito, Cal.	E. Gray	3-roller	Permanent	July 1, 1884	May 31, 1885	336
XII	Saint Paul, Alaska	William J. Fisher	do	do	December 1, 1883	May 26, 1884	177
	do	F. Sargent	do	do	May 27, 1884	March 31, 1885	310

There are two 3-roller gauges and one 2-roller gauge in the Office, all ready for use.

The records received from the automatic gauges, and also those sent to the Office by the hydrographic parties, are inspected as soon as received; and reduced by the Tidal Division. Notices of them may be found in the accounts of work done in the different sections. The observations of the hydrographic parties are mostly made with staff or box gauges, and many of them only during daylight. This mode gives results of a fairly approximate nature for tidal phenomena on the Atlantic Coast, but on the coasts of the Pacific and Gulf of Mexico observations should be kept up both day and night, to obtain an accurate reduction for the soundings.

#### OFFICE-WORK.

The observers at the permanent stations where automatic gauges are used have been taught to tabulate the high and low waters and hourly ordinates from the curves, before sending these to the Office, and to send first the tabulations, and afterward the curves. The loss by mails is thus made less serious, and the observers become more skillful and careful, while the amount of Office work is considerably reduced.

The observations obtained by the automatic gauges and by the hydrographic parties are reduced and discussed according to the most approved methods in the Tidal Division, and the

results are used in the Chart tables, in the predictions, and for other purposes, and enable the Division to furnish a large amount of information about tides to Officers of the Survey, Civil and United States Engineers, and others, the demand for which is rapidly increasing.

"Tide Tables," containing the predictions for the Atlantic and Pacific Coasts of the United States for the year 1886, have been computed by the Tidal Division, and are being published, making the twentieth year of the series.

The predicting-machine invented by Professor Ferrel was more extensively used in this work than in predicting for 1885, and for some of the places improved constants were employed. Considerable labor was required in computing these constants, verifying them by trials, and in adapting these tables to the new mode of reckoning time.

The following computers have been employed in this Division in the course of the year: R. S. Avery, L. P. Shidy, M. Thomas, and C. B. Turnbull, in the Office; and J. G. Spaulding and L. J. Ferrel out of it.

Mr. Avery was in charge of the Division, and inspected all the tidal observations received, attended to the correspondence with observers and others relating to tides, planned and supervised the work on tides and tide-gauges, prepared the predictions for printing and read the proofs, and computed when not otherwise engaged.

Mr. Shidy tabulated and reduced many observations received from the automatic gauges and hydrographic parties, predicted for some places where the old methods had to be used, and with the predicting-machine for others; improved the tables for calculating components for the machine, computed and tested various components, and aided efficiently in much miscellaneous work. Miss Thomas worked on the simplest reductions and on the hourly ordinates for permanent stations, aiding sometimes on miscellaneous work and copying. Miss Turnbull has been employed in copying, tracing, and tabulating tides, and sometimes in aiding in easy reductions and miscellaneous work. Mr. Spaulding aided in computing components for use in making the predictions, in addition to his services as Tidal Observer at Pulpit Harbor.

Miss Ferrel worked on the discussion of observations by the Harmonic Analysis to find components to use in the predicting-machine, and for other purposes.

Respectfully submitted.

R. S. AVERY,  
*In charge Tidal Division.*

Mr. B. A. COLONNA,  
*Assistant in charge Coast and Geodetic Survey Office.*

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REPORT OF THE DRAWING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR  
ENDING JUNE 30, 1885.

COAST AND GEODETIC SURVEY OFFICE,  
*Washington, June 30, 1885.*

DEAR SIR: In conformity with regulations I herewith submit the usual annual report of the work done by this division during the fiscal year ending June 30, 1885.

The following statement of work executed by the draughtsmen and the accompanying lists of charts and sketches, completed or in progress, together with the list of information (included in Appendix No. 3) furnished to meet special requests from official and non-official sources, will serve to give an idea of the amount of work performed during the past year.

Besides the exhibit given in the above-mentioned statements, there have been constructed for field operations forty-four projections of various scales for topographical work, and fifty-five projections for hydrographic operations.

Diagrams in great numbers have been drawn for photolithographing to illustrate papers in the annual reports.

An average number of charts for quick publication by the photolithographic process were finished; a number of plane-table sheets were prepared and reproduced upon their original scales



by the same process, and have given general satisfaction. The standard longitude has been marked upon the engraved plates as necessity demanded.

When not employed upon drawings of reduced scale for engraving upon copper, several of the draughtsmen were engaged in inking and lettering plane-table sheets for ultimate publication without material reduction in scale.

A synopsis of the work performed by each draughtsman during the fiscal year is given below.

Mr. A. Lindenkohl has drawn the additions to the annual progress sketches, reduced the topography and hydrography of a chart of Puget Sound from Admiralty Head to Seattle, scale 1-80000, and commenced the drawing of the upper part of the same from Seattle to Olympia; made additions to the series of Pacific Coast sailing-charts, scale 1-200000; compiled a new edition of the hydrography for Coast Chart No. 21, Sandy Hook to Barnegat Inlet, scale 1-80000; continued the topographical reduction of Coast Chart No. 2, Seal Island Light to Petit Manan Light, scale 1-80000, and the hydrography of Coast Chart No. 14, Long Island Sound Eastern sheet, new edition, scale 1-80000, and has been engaged in keeping up to date the general charts of the Atlantic and Gulf Coasts, scale 1-400000, together with the sailing-charts, scale 1-1200000; he has also compiled for photolithographing, a large-scale chart of Newport Harbor and the entrance to Narragansett Bay, and partly reduced for engraving Charts Nos. 5 and 6 of the Columbia River, Oregon, from Kalama to Portland, scale 1-40000. He has also constructed projections for field parties, projections on copper, and made verifications and constructed numerous diagrams.

Mr. H. Lindenkohl has engraved upon stone the annual additions to a number of progress sketches, and drawn in a fine style for photolithographing, charts of New London Harbor and entrance to the Thames River; Thames River, New London to Norwich, scale 1-20000; Newport Harbor and entrance to Narragansett Bay, scale 1-20000; reduced topography and hydrography for general charts of the coast No. I, Quoddy Head to Cape Cod; No. VI, Cape Hatteras to Cape Romain; No. XI, Key West to Tampa Bay; No. XII, Tampa Bay to Cape San Blas, scales 1-400000; made additions to a chart of New York Harbor for the Pilot Commissioners; drawn for photolithographing several charts of harbors and sounds in Alaska; continued the hydrographic and topographical reductions for Pacific Coast Chart No. 3, Point Concepcion to San Louis Obispo, Cal., scale 1-200000; engraved diagrams on stone illustrating papers in the annual report; and constructed field projections and projections upon copper. He has also completed the reduction of topography, scale 1-40000, of the Columbia River, Sheets Nos. 5 and 6, Kalama to Portland, and has been employed upon various kinds of miscellaneous work.

Mr. C. Junken has been generally engaged upon hydrographic reductions of various scales, as follows: Coast Chart No. 50, Cape Fear River and approaches, scale 1-80000; Coast Chart No. 2, Seal Island Light to Petit Manan Light, scale 1-80000; Coast Chart No. 77, Tampa Bay, Florida, scale 1-80000; entrance to Cape Fear River, North Carolina, scale 1-30000; Coast Chart No. 76, Charlotte Harbor to Tampa Bay, Florida, scale 1-80000; Coast Chart No. 75, Charlotte Harbor and San Carlos Bay, Florida, scale 1-80000; topography and hydrography of Coast Chart No. 47, Cape Lookout and vicinity; hydrography of Port Gamble and vicinity, Washington Territory, scale 1-20000; hydrography for a new edition of Savannah River, Georgia, scale 1-40000; additional hydrography for Pacific Coast Chart No. 6, San Francisco to Point Arena, California, scale 1-200000; has compiled for photolithographing charts of Fisher's Island Sound, scale 1-40000, and Gray's Harbor, Washington Territory, scale 1-40000. He was also employed in constructing field projections and copper-plate projections. From the 15th of November to the 3d of January, Mr. Junken was engaged on the special duty of determining and marking points on the boundary line between Maryland and Virginia, in the vicinity of Pocomoke Sound.

Mr. E. J. Sommer has reduced to the publication scale the hydrography of New London Harbor, scale 1-20000; topography and hydrography of coast chart No. 62, Cape Canaveral southward, scale 1-80000; coast chart No. 63, Indian River Shoals to Jupiter Inlet Light, scale 1-80000; made smooth drawings for photolithographing of several harbors in Alaska; also prepared for the same process the original hydrographic and topographical sheets, coast of California, south of Point Pinos, including Carmel Bay, to be upon the scale of 1-12000. He has made field projections, copper-plate projections, and done other miscellaneous work.

Mr. T. J. O'Sullivan has made finished drawings for photolithographing, sketches of the trans-

continental triangulation from San Francisco eastward, scale 1-2000000; harbors in Alaska; inked and lettered plane-table sheets south side Long Island; Hood's Canal and Puget Sound; reduced additional topography for harbor chart coast of Maine, No. 11, Cape Split to Schoodic Island, scale 1-40000; made verifications, finished sketches and diagrams for annual report; made tracings and done general lettering.

Mr. P. Erichsen, in addition to calculating the areas of engraved topography for use in the Engraving Division, was engaged in inking plane-table sheets of Hood's Canal, Washington Territory; coast of California; Chandler's River Bay, Maine; shores of the Delaware Bay, and Indian River, Florida. He also made tracings and mechanical drawings, and did verification.

Mr. L. Karcher rejoined the office in July, and has principally been engaged in constructing numerous field projections, making projects and tracings, and has been engaged in other miscellaneous duties.

Mr. E. H. Fowler has inked and lettered plane-table sheets coast of New Jersey; Columbia River, Oregon; coast of California, and south side Long Island; reduced topography for coast chart No. 37, scale 1-80000, Norfolk and vicinity; additional topography for chart of Savannah River, Georgia, scale 1-40000, and been engaged on small diagrams and tracings. He has made the finished drawing for a new edition of the chart of Gray's Harbor, Washington Territory, scale 1-40000.

Mr. E. Molkow has inked and lettered plane-table sheets of New London and vicinity, Conn.; coast of California; coast north of Cape Henlopen; south side of Long Island; Chandler's River Bay, Maine; Machiasport and vicinity, Maine; made projects and diagrams, and attended to the measurements of the topographical sheets for the annual table of statistics.

Mr. A. B. Graham continued the construction of hydrographic projections, projects, photolithographic drawings, and miscellaneous tracings. Mr. Graham resigned in April.

Mr. J. C. Barr was occupied as clerk to the division during part of the year; afterwards his time was given to the coloring of lights and buoys on charts.

Mr. J. H. Barker has been employed in coloring buoys and light-houses on charts and in making additions and corrections to the newly printed charts.

Yours respectfully,

W. T. BRIGHT.

Mr. C. O. BOUTELLE,  
*Assistant in Charge of Office.*

### DRAWING DIVISION.

*Charts completed or in progress during the year ending June 30, 1885.*

1. Topography. 2. Hydrography.

Number of charts.		Title of charts.	Scale.	Draughtsmen.	Remarks.
Series.	Catalogue.				
		ATLANTIC COAST. GENERAL COAST CHARTS.			
I	6	Quoddy Head to Cape Cod.....	1-400,000	1. H. Lindenkohl.....	Additions.
VI	11	Cape Hatteras to Cape Romain.....	1-400,000	1. H. Lindenkohl.....	Do.
XI	16	Key West to Tampa Bay.....	1-400,000	1, 2. A. Lindenkohl. 1. H. Lindenkohl.	Do.
XII	17	Tampa Bay to Cape San Blas.....	1-400,000	1. H. Lindenkohl. 2. A. Lindenkohl.	Do.
XIV	19	Mobile Bay to Atchafalaya Bay.....	1-400,000	1, 2. A. Lindenkohl.....	Do.

H. EX. 18—14

*Charts completed or in progress during the year ending June 30, 1885—Continued.*

1. Topography. 2. Hydrography.

Series.	Catalogue.	Title of charts.	Scale.	Draughtsmen.	Remarks.
<b>ATLANTIC COAST—Continued.</b>					
<b>COAST CHARTS.</b>					
2	102	Seal Island Light to Petit Manan Light .....	1-80,000	2. C. Junken. 1. A. Lindenkohl. 2. L. Karcher. 2. H. Lindenkohl.	In progress.
3	103	Frenchman's and Blue Hill Bays .....	1-80,000	1. A. Lindenkohl. 1. H. Lindenkohl.	Additions.
14	114	Newport to Plum Island Light .....	1-80,000	1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl.	In progress.
31	131	Entrance to Chesapeake Bay, Hampton Roads, &c ..	1-80,000	1, 2. A. Lindenkohl .....	Additions.
21	121	New York Bay and Harbor .....	1-80,000	2. A. Lindenkohl .....	Do.
37	137	Cape Henry to Currituck Beach .....	1-80,000	1, 2. E. J. Sommer. 1. E. H. Fowler.	Do.
47	147	Cape Lookout and vicinity .....	1-80,000	1, 2. C. Junken .....	Completed.
50	150	Cape Fear River and approaches .....	1-80,000	1, 2. C. Junken .....	Do.
53	153	Winyah Bay to Long Island, S. E. ....	1-80,000	2. A. Lindenkohl .....	Additions.
62	162	Cape Canaveral to Indian River Light .....	1-80,000	1, 2. E. J. Sommer .....	Completed.
63	163	Indian River Light to Jupiter Inlet Light .....	1-80,000	1. E. J. Sommer .....	In progress.
75	175	Charlotte Harbor and San Carlos Bay .....	1-80,000	2. C. Junken .....	Additions.
76	176	Charlotte Harbor to Tampa Bay .....	1-80,000	2. C. Junken .....	Completed.
77	177	Tampa Bay and approaches .....	1-80,000	2. C. Junken .....	Additions.
94	194	Mississippi River, from the Passes to Grand Prairie..	1-80,000	1. H. Lindenkohl .....	Do.
105	205	Galveston Bay to Oyster Bay .....	1-80,000	1. A. Lindenkohl .....	Do.
<b>HARBOR CHARTS.</b>					
11	305	Cape Split to Schoodic Island, Me. ....	1-40,000	1, 2. T. J. O'Sullivan .....	Additions.
	318	Bar Harbor, Me. ....	1-10,000	1. H. Lindenkohl .....	Do.
	306	Frenchman's Bay and Somes' Sound .....	1-40,000	1. E. Molcow .....	Do.
	353 <sup>a</sup>	Newport Harbor and Entrances to Narragansett Bay ..	1-20,000	1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl.	Photo-lith.; completed.
	358	Fisher's Island Sound .....	1-40,000	1, 2. C. Junken. 1, 2. H. Lindenkohl.	Do.
	359	New London Harbor and Entrance to Thames River..	1-20,000	1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl.	Do.
	359 <sup>a</sup>	Thames River, New London to Norwich .....	1-20,000	1, 2. H. Lindenkohl. 1. T. J. O'Sullivan.	Do.
	360 <sup>a</sup>	New York Entrance .....	1-40,000	1. A. Lindenkohl .....	Additions.
	360 <sup>a</sup>	New York Harbor and parts of Hudson and East Rivers.	1-10,000	2. A. Lindenkohl. 2. H. Lindenkohl (for Board of Pilot Commissioners).	Completed.
	424	Cape Fear River Entrance .....	1-80,000	2. C. Junken .....	Additions.
	440	Savannah River and Wassaw Sound .....	1-40,000	1. E. H. Fowler. 2. C. Junken ..	Do.
<b>PACIFIC COAST.</b>					
<b>HARBOR CHARTS.</b>					
	621 <sup>a</sup>	San Francisco Entrance (new edition) .....	1-40,000	2. L. Karcher .....	Do.
	641 <sup>c</sup>	Columbia River, Kalama to Willow Bar .....	1-40,000	1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl.	In progress.
	641 <sup>d</sup>	Columbia River, Willow Bar to Portland .....	1-40,000	1. H. Lindenkohl .....	Do.
	643	Gray's Harbor, W. T. (new edition) .....	1-40,000	2. C. Junken. 1, 2. E. H. Fowler.	Photo-lith.; completed.
	650	Port Gamble, W. T. (new edition) .....	1-20,000	1, 2. C. Junken .....	Completed.
<b>SAILING CHARTS.</b>					
	673	Point Concepcion to San Luis Obispo .....	1-200,000	2. H. Lindenkohl .....	Additions.
	676	San Francisco to Point Arena .....	1-200,000	1, 2. C. Junken .....	Do.
	662 <sup>a</sup>	Puget Sound, Admiralty Head to Olympia .....	1-80,000	1, 2. A. Lindenkohl. 1. H. Lindenkohl.	Completed.
	662 <sup>b</sup>	Puget Sound, Seattle to Olympia .....	1-80,000	1, 2. A. Lindenkohl .....	In progress.

REPORT OF THE ENGRAVING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR  
ENDING JUNE 30, 1885.U. S. COAST AND GEODETIC SURVEY OFFICE,  
Washington, July 1, 1885.

SIR: I respectfully submit the following report of work executed in the Engraving Division during the year ending June 30, 1885.

The corrections to the plates, required before printing for issue, have continued to increase in number and from the numerous additions from resurveys have required more labor than in former years.

Four hundred and twenty-one chart plates and fourteen sketches were corrected, in addition to extensive alterations in new printing plates electrotyped from the standard altos. We have also had the usual amount of cleaning electrotypes, erasures from altos, arranging and drawing titles, general lettering and notes, marking instruments, &c.

Several important charts have been well advanced in addition to those completed, but the time required in correcting the printing plates and bringing up new electrotype copies, seriously interferes with the production of new charts.

This work is necessarily of the first importance, as the published charts must be kept up to date so far as as information received will permit; the time required for it is on the increase, and I cannot urge upon you too strongly the consideration of suitable methods to bring the surveys before the public in preliminary form, and thus give more time for the completion of the finished charts without delaying the publication of important new surveys.

The engravers have been employed as follows: Messrs. Joseph Enthoffer, W. A. Thompson, H. C. Evans, R. F. Bartle, and E. J. Enthoffer, on Topography and Sand. Messrs. E. A. Maedel, A. Petersen, J. G. Thompson, and F. Courtenay, on Lettering. Messrs. E. H. Sipe, W. H. Davis, and A. C. Ruebsam, on Lettering and Miscellaneous Corrections; and Messrs. H. M. Knight and T. Wasserbach, on Lettering, Sand, and Miscellaneous Corrections.

The electrotyping of the copper plates has continued under my direction with the immediate supervision of Dr. A. Zumbrock, assisted by Frank Over.

The improvements made in the batteries have resulted in more regular work. The batteries do not break down and are more readily cared for, requiring much less labor. Observations are now being made to determine the relative values of the carbon and our old silver plates.

The printing for the chart room during the year has fallen off about 14 per cent. of the preceding year's work, or over 4,500 impressions. This is largely due to the interruption caused by building the addition to the printing room, and the failure of the contractors to keep up the supply of chart paper. For about two months it was impossible to fill the requisitions from the chart room with the usual promptness, which has doubtless resulted in a diminished issue to the sale agents.

The new press room affords much better light and facilities for work, and being on a level with the street, instead of below it, will doubtless prove more healthful to the workmen. It is sufficiently large to accommodate the new 38-inch copper-plate press, in addition to the two old presses, and will permit the requisite increase of force when the demand for charts shall make an increase necessary.

The force of printers has remained the same; the presses have been in charge of Mr. F. Moore, foreman, and Messrs. D. N. Hoover and James L. Smith.

Mr. John H. Smoot has continued as clerk to the division, and I take pleasure in commending his strict attention to his duties, and the very satisfactory chart proof-reading he now furnishes.

*Statistics of work.*

## ENGRAVING.

Number of plates completed:

Charts .....	11
New editions .....	9
Sketches and illustrations .....	5
	<hr/>
	25
	<hr/>

## Number of plates continued :

Charts .....	15
New editions .....	1
Sketches and illustrations .....	4
	<hr/>
	20

## Number of plates commenced :

Charts .....	8
New editions .....	12
Sketches and illustrations .....	5
	<hr/>
	25

## Number of plates corrected for printing :

Charts .....	421
Sketches .....	14
	<hr/>
	435

## Number of unfinished plates on hand at the close of the year :

Charts .....	41
Sketches and illustrations .....	28
	<hr/>
	69

## ELECTROTYPING.

Number of pounds of copper deposited .....	2, 534
Number of square inches on which deposit was made .....	124, 937
	<hr/>
Number of copper plates made:	
Bassos .....	46
Altos .....	61
	<hr/>
	107

Of which number 13 basso and 14 alto plates were for the Engineer Corps, U. S. A. (Lake Survey), and 7 basso and 7 alto plates for the Hydrographic Office, Navy Department. In photographing, 44 negatives were made and 127 prints.

## PRINTING.

Number of impressions for Chart Room .....	26, 488
Number of impressions for Assistant in charge of Office .....	1, 221
Number of impressions for Engraving Division .....	1, 652
Number of impressions for Hydrographic Inspector .....	1, 032
Number of impressions for Lithographer (transfer proofs) .....	224
Number of impressions for Atlantic Coast Pilot, vol. 4 Charts and Views ....	5, 436
	<hr/>
Total .....	36, 053

I append hereto a list of the copper plates that were completed, continued, or commenced during the year.

I am, sir, yours, very respectfully,

HERBERT G. OGDEN,

*Assistant Coast and Geodetic Survey,*

*In charge of Engraving Division.*

C. O. BOUTELLE, Esq.,

*Assistant in charge Office and Topography.*

*Plates completed, continued, or commenced during the fiscal year ending June 30, 1885.*

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

Catalogue No.	Plate No.	Title.	Scale.	Engravers and work.
COMPLETED.				
14	1843	Cape Canaveral to Fowey Rocks.....	1-400,000	1, 2. R. F. Bartle and W. A. Thompson. 4. E. A. Maedel and J. G. Thompson.
145	1725	Cape Hatteras to Ocracoke Inlet.....	1-80,000	4. T. Wasserbach and E. A. Ruebsam.
181	1450	Apalachee Bay.....	1-80,000	3. F. Courtenay and E. A. Ruebsam. 4. T. Wasserbach and A. C. Ruebsam.
208	1247	Paseo Cavallo, Lavaca and San Antonio Bays.....	1-80,000	1, 2. W. A. Thompson. 4. A. C. Ruebsam.
209	1248	Aransas Pass, Aransas and Copano Bays.....	1-80,000	2, 3. W. A. Thompson and J. G. Thompson. 4. A. C. Ruebsam.
306	1186	Frenchman's Bay and Eastern Part of Mount Desert Island.	1-40,000	4. E. A. Maedel, J. G. Thompson, and A. C. Ruebsam.
307	1285	Blue Hill Bay and Western Part of Mount Desert Island.	1-40,000	1, 2, 3. W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, W. H. Davis, and A. C. Ruebsam.
308	1376	Approaches to Blue Hill Bay and Eggemoggin Reach..	1-40,000	2, 3. W. A. Thompson. 3. H. M. Knight and H. C. Evans. 4. J. G. Thompson and A. C. Ruebsam.
676	1741	San Francisco to Point Arena.....	1-200,000	1, 2, 3. W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, and A. C. Ruebsam.
681a	1790	Approaches to the Columbia River.....	1-200,000	4. J. G. Thompson.
621a	1829	San Francisco Entrance.....	1-40,000	1, 2, 3. W. A. Thompson. 3. T. Wasserbach. 4. A. Petersen, J. G. Thompson, and W. H. Davis.
205	1216	Galveston Bay to Oyster Bay, edition 1884.....	1-80,000	3. W. A. Thompson and T. Wasserbach. 4. A. Petersen, T. Wasserbach, and W. H. Davis.
424	1161	Cape Fear River Entrance, edition 1884.....	1-80,000	1, 2, 3. H. M. Knight. 3, 4. T. Wasserbach. 4. A. C. Ruebsam.
520	1830	Galveston Entrance, edition 1884.....	1-40,000	3. T. Wasserbach. 4. A. Petersen, W. H. Davis, and A. C. Ruebsam.
30	97	Galveston Bay, edition 1884.....	1-200,000	3, 4. W. H. Davis.
111	1809	Monomoy and Nantucket Shoals to Muskeget Channel, edition 1885.	1-80,000	3. H. M. Knight. 4. H. M. Knight, E. H. Sipe, and A. C. Ruebsam.
194	1845	Mississippi River from the Passes to Grand Prairie, edition 1885.	1-80,000	1, 2, 3. W. A. Thompson. 4. A. C. Ruebsam.
318	1857	Bar Harbor, Mount Desert Island, edition 1885.....	1-10,000	1, 2. E. J. Enthoffer. 3. W. A. Thompson. 4. W. H. Davis.
344	1836	Monomoy Passage, edition 1885.....	1-40,000	3, 4. H. M. Knight. 4. F. Courtenay and A. C. Ruebsam.
650	1851	Port Gamble, edition 1885.....	1-20,000	1, 2, 3. R. F. Bartle. 4. F. Courtenay and W. H. Davis
	1850	Progress Sketch No. 6, West Coast of Florida, Cape Sable to Charlotte Harbor.	1-200,000	1, 4. A. C. Ruebsam.
	1839	Atlantic Coast Pilot Chart, Cape Henry to Cape Lookout.	1-400,000	4. A. C. Ruebsam.
	1840	Atlantic Coast Pilot Chart, Cape Lookout to Cape Roman.	1-400,000	4. A. C. Ruebsam.
	1864	Atlantic Coast Pilot Chart, Frying Pan Shoals to Wasaw Sound.	1-400,000	4. A. C. Ruebsam.
	1726	Atlantic Coast Pilot View, Tybee Entrance, Tybee Roads, &c.		4. W. H. Davis.
CONTINUED.				
D	1653	Gulf of Mexico.....	1-2,100,000	3. W. A. Thompson. 4. E. A. Maedel and J. G. Thompson.
102	1742	Seal Island to Petit Manan.....	1-80,000	1, 2. Joseph Enthoffer. 3. H. M. Knight. 4. J. G. Thompson and A. C. Ruebsam.
150	1841	Cape Fear and Approaches.....	1-80,000	1, 2. H. C. Evans. 4. A. Petersen.
153	1503	Winyah Bay to Long Island.....	1-80,000	4. H. M. Knight.
180	1746	Cedar Keys to Deadman's Bay.....	1-80,000	3. E. A. Ruebsam. 4. F. Courtenay and A. C. Ruebsam.
184	1601	Saint Joseph's Bay to Saint Andrew's Bay.....	1-80,000	3, 4. H. M. Knight. 4. A. C. Ruebsam.
185	1498	Saint Andrew's Bay to Choctawhatchee Inlet.....	1-80,000	4. A. C. Ruebsam.
192	1537	Chandeleur and Breton Island Sounds.....	1-80,000	3. F. Courtenay and E. A. Ruebsam.
204	1316	Galveston Bay.....	1-80,000	3, 4. T. Wasserbach. 4. A. Petersen and W. H. Davis.
210	1778	Corpus Christi Bay and Pass.....	1-80,000	3. E. A. Ruebsam. 4. A. Petersen and A. C. Ruebsam.
205	1821	Pleasant Bay to Prospect Harbor.....	1-40,000	1, 2. R. F. Bartle. 4. A. Petersen and E. A. Ruebsam.
350a	1796	Thames River and New London Harbor.....	1-40,000	1, 2, 3. H. M. Knight. 4. A. Petersen.

*Plates completed, continued or commenced during the fiscal year ending June 30, 1885.*

1. Outlines. 2. Topography. 3. Sailing. 4. Lettering.

Catalogue No.	Plate No.	Title.	Scale.	Engravers and work.
CONTINUED.				
401e	1679	James River No. 5, Kingsland Creek to Richmond.....	1-20,000	3, 4. H. M. Knight.
673	1800	Point Conception to San Luis Obispo.....	1-200,000	4. A. Petersen.
669	1828	San Luis Obispo Bay.....	1-20,000	1, 2. E. J. Enthoffer. 3. T. Wasserbach.
	1789	Trinidad Harbor, California.....	1-40,000	4. A. C. Ruebsam.
	1793	Saint George's Reef, Crescent City, and Cape Orford.....	1-80,000	4. A. C. Ruebsam.
	1805	San Francisco Entrance.....	1-80,000	4. A. C. Ruebsam.
	1820	San Diego Bay, California.....	1-100,000	1, 2. E. J. Enthoffer. 4. F. Courtenay.
120	1785	New York Bay and Harbor, new edition.....	1-80,000	1, 2. W. A. Thompson. 3. H. M. Knight. 4. A. Petersen and F. Courtenay.
COMMENCED.				
16	1855	General Coast Chart No. 11, Key West to Tampa Bay.....	1-400,000	1, 2. R. F. Bartle. 4. A. Petersen.
147	1861	Cape Lookout.....	1-80,000	1, 2. Joseph Enthoffer.
148	1862	Bogue Inlet to New Topsail Inlet.....	1-80,000	1, 2. R. F. Bartle.
162	1844	Cape Canaveral southward to latitude 27° 41'.....	1-80,000	1, 2. H. C. Evans. 4. E. H. Sipe.
176	1848	Lemon Bay to Tampa Bay.....	1-80,000	1, 2. R. F. Bartle. 4. A. Petersen and E. A. Ruebsam.
379	1847	Delaware Breakwater.....	1-20,000	1, 2. E. J. Enthoffer. 3. E. A. Ruebsam. 4. A. Petersen and F. Courtenay.
685	1834	Admiralty Inlet.....	1-80,000	1, 2. Joseph Enthoffer. 4. A. Petersen.
690	1865	Commencement Bay.....	1-20,000	1, 2. E. J. Enthoffer.
80	97	Galveston Bay, new edition.....	1-200,000	3, 4. W. H. Davis.
111	1809	Monomoy and Nantucket Shoals to Muskeget Channel, new edition.....	1-80,000	3, 4. H. M. Knight. 4. E. H. Sipe and A. C. Ruebsam.
121	1856	Sandy Hook to Barnegat Inlet, new edition.....	1-80,000	4. F. Courtenay.
177	1852	Tampa Bay, new edition.....	1-80,000	3. E. A. Ruebsam. 4. F. Courtenay.
194	1845	Mississippi River, from the Passes to Grand Prairie, new edition.....	1-80,000	1, 2, 3. W. A. Thompson. 4. A. C. Ruebsam.
205	1216	Galveston Bay to Oyster Bay, new edition.....	1-80,000	3. W. A. Thompson and T. Wasserbach. 4. A. Petersen, T. Wasserbach, and W. H. Davis.
318	1837	Bar Harbor, Mount Desert Island, new edition.....	1-10,000	1, 2. E. J. Enthoffer. 3. W. A. Thompson. 4. W. H. Davis.
344	1836	Monomoy Passage, new edition.....	1-40,000	3, 4. H. M. Knight. 4. F. Courtenay and A. C. Ruebsam.
424	1161	Cape Fear River Entrance, new edition.....	1-30,000	2, 3. H. M. Knight. 4. A. C. Ruebsam.
520	1836	Galveston Entrance, new edition.....	1-40,000	3. W. A. Thompson. 4. A. Petersen, W. H. Davis, and A. C. Ruebsam.
650	1851	Port Gamble, new edition.....	1-20,000	1, 2, 3. R. F. Bartle. 4. F. Courtenay and W. H. Davis.
440	1831	Savannah River and Wassaw Sound, new edition.....	1-40,000	1, 2. W. A. Thompson. 4. A. Petersen.
	1859	Progress Sketch section 6 West Coast of Florida, Cape Sable to Charlotte Harbor.....	1-200,000	1, 4. A. C. Ruebsam.
	1839	Atlantic Coast Pilot Chart, Cape Henry to Cape Lookout.....	1-400,000	4. A. C. Ruebsam.
	1840	Atlantic Coast Pilot Chart, Cape Lookout to Cape Ro-main.....	1-400,000	4. A. C. Ruebsam.
	1864	Atlantic Coast Pilot, Chart Frying Pan Shoals to Wassaw Sound.....	1-400,000	4. A. C. Ruebsam.
	1858	Atlantic Coast Pilot Chart Coast, and Inland Passage from Charleston to Fernandina.....	1-400,000	4. A. C. Ruebsam.

REPORT OF THE MISCELLANEOUS DIVISION FOR THE YEAR ENDING JUNE 30, 1885.

U. S. COAST AND GEODETIC SURVEY OFFICE,  
Washington, August 25, 1885.

SIR: I have the honor to submit herewith the report of this Division for the year ending June 30, 1885.

The work of the Division was of the same general character as in former years. The Annual

Report of the Superintendent for the year ending June 30, 1883, which had been sent to press in the preceding fiscal year, was published, and the usual distribution of the volume was made.

First editions of the Pacific Coast Pilot, Alaska, Part 1 (Dixon Entrance to Yakutat Bay, with the Inland Passages), and of Subdivision 19, Atlantic Coast Pilot (Cape Henry to Winyah Bay, and Inside Passages), were published. Subdivision 20, Atlantic Coast Pilot (Winyah Bay to Savannah, with the Inside Passage to Fernandina) was sent to press. A revised edition of Appendix 22, Report for 1882 (Report of a conference on gravity determinations), and the "Summary Report of the Progress of the United States Coast and Geodetic Survey for the fiscal year ending with June, 1884," were also printed. The Annual Report of the Superintendent for the fiscal year ending June 30, 1884, was sent to press, and satisfactory progress made towards its publication. It is expected that this volume will be ready for distribution before the Report for 1885 is submitted to Congress. The Tide Tables for the Pacific Coast for the year 1886 were also sent to press.

The following aggregates of publications of the Survey were received from the Public Printer during the year:

	Copies.
Annual Report for 1883 .....	3,019
Appendices to Annual Reports (extra copies).....	4,600
Notices to Mariners, Nos. 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62.....	6,800
Atlantic Local Coast Pilot, Subdivision 19 .....	522
Pacific Coast Pilot, Alaska, Part 1 .....	199
Summary of Report of Superintendent for 1884 .....	300
Description of Coast and Geodetic Survey Exhibit at the Cotton Centennial Exposition at New Orleans .....	1,000

A detailed list of the above-mentioned publications is appended hereto.

The usual distribution of the publications of the Survey to Institutions, individuals, and the Departments was made, and the Notices to Mariners and Appendices to Annual Reports, in pamphlet form, were distributed gratuitously, as heretofore.

Two thousand four hundred and eighty-eight copies of the Annual Reports were distributed during the year; also, six hundred and eighty-six copies of the Atlantic Coast Pilot, including Subdivisions, and one hundred and ninety-two copies of the Pacific Coast Pilot.

There were received in the Chart-room during the year 29,525 sheets of charts, of which 23,760 were copper-plate impressions, and 5,765 were printed from stone. Twelve thousand one hundred and sixty-three copies were furnished to the several Executive Departments and to Senators and Representatives, and 14,035 sheets were deposited with Sale Agents. The total issue of charts during the year was 28,905 copies, being 4,733 copies less than the total issue of the preceding year. (See statement appended hereto.)

Mr. Hugo G. Eichholtz has continued in charge of the Chart-room, and the issue of charts has been made under his immediate supervision.

Mr. H. O. French has been in charge of the Carpenter shop as Chief Carpenter. The carpenter work of the office, including the wood-work of instruments, making packing-cases and patterns, packing instruments for transportation, the construction of frames, vats, &c., for electrotyping, press-boards, &c., for the plate-printing room, repairs of furniture, &c., has been done by Mr. French, assisted by Messrs. G. F. Cox and G. W. Clarvoe.

Mr. R. T. Bassett has been in charge of the map-mounting room, as heretofore. Mr. N. Y. Cavitt performed the duties of janitor until the 1st of May, 1885, when he was succeeded by Mr. W. M. Long, who has since acted in that capacity. Upon the promotion of Mr. Long from watchman to janitor Mr. Charles O. Rockwell was appointed watchman by the Superintendent. Charles E. Brown was employed as night fireman from November 26, 1884, to May 31, 1885. With these two exceptions, there have been no changes in the force of watchmen, messengers, and laborers.

Yours, respectfully,

M. W. WINES,  
*Chief of Miscellaneous Division.*

B. A. COLONNA, Esq.,  
*Assistant in charge of Office and Topography.*



*List of Publications of the Coast and Geodetic Survey received from the Public Printer during the fiscal year ending June 30, 1885.*

Name of publication.	Number of copies.	Name of publication.	Number of copies.
Annual Report for 1883 .....	3, 019	Sitka Harbor and Hooniah Sound, through Olga Strait, Neva Strait, and Peril Straits, Alaska .....	1, 000
Atlantic Coast Pilot, Subdivision 19—Cape Henry to Win- yah Bay, and Inside Passages .....	522	No. 62.—Shoal developed near Marquesas Keys, Florida .....	500
Pacific Coast Pilot, Alaska, Part 1—Dixon Entrance to Ya- kutat Bay, with the Inland Passages .....	499	APPENDICES TO THE REPORT FOR 1883.	
Summary of Report of Superintendent for 1884 .....	300	No. 6.—Descriptive Catalogue of Publications .....	500
Report of a conference on Gravity Determinations. (Re- vised edition of Appendix 22, Report for 1882) .....	200	No. 8.—The Estuary of the Delaware .....	400
Short descriptions of Articles forming the Coast and Geo- detic Survey Exhibit at the Cotton Centennial Exposit- tion, New Orleans, La., 1884-'85. ....	1, 000	No. 9.—Tides at Sandy Hook .....	200
NOTICES TO MARINERS.		No. 10.—Maxima and Minima Tide-Predicting Machine....	200
No. 52.—Dangerous Rock in East River, New York .....	500	No. 11.—On the length of the Yolo Base Line, California...	300
No. 53.—Changes in the Pilotage Laws of the Port of New York .....	1, 000	No. 12.—Results for Atmospheric Refraction from Hypso- metric measures made in California in 1880 .....	500
No. 54.—Rocks recently reported on the Coast of New Eng- land .....	500	No. 13.—Report upon Magnetic Observations made at the U. S. Polar Station Ooglaamie, Point Barrow, Alaska, 1881-1882-1883 .....	300
No. 55.—Dangerous ledges developed in the resurvey of Long Island Sound .....	500	No. 14.—Standard Topographical Drawings, First and second series .....	500
No. 56.—Shoal developed in Vineyard Sound .....	500	No. 15.—Transit of Mercury, November 7, 1881, observed at Yolo Base, California .....	100
No. 57.—Discovery of a rock in Security Bay, Chatham Strait, Alaska .....	500	No. 16.—The Transit of Venus, 1882 .....	200
No. 58.—Development of shoals in Narragansett Bay, R. I., and Block Island Sound .....	500	No. 18.—Field Catalogue of Time and Circumpolar Stars for 1885 .....	400
No. 59.—Changes in main ship-channel, Vineyard Sound .....	500	No. 19.—Determinations of Gravity at stations in Pennsylv- vania, 1879-1880 .....	300
No. 60.—Sailing directions for Wrangell Strait, Alaska .....	800	APPENDIX TO REPORT FOR 1884.	
No. 61.—Sailing directions for Inland Passage between		No. 8.—The run of the Micrometer .....	500

*Charts received in and issued from the Chart-room during the fiscal year ending June 30, 1885.*

To whom issued.	Number of sheets—			
	Received.	Issued.	On hand.	
			July 1, 1884.	June 30, 1885.
.....	29, 525	.....	35, 876	36, 496
Executive Departments .....		10, 740		
Senators and Representatives .....		1, 423		
Institutions .....		927		
Sale Agents .....		14, 035		
Foreign Governments .....		367		
Miscellaneous .....		1, 413		
Total .....	29, 525	28, 905	35, 876	36, 496

ARCHIVES AND LIBRARY U. S. COAST AND GEODETIC SURVEY OFFICE.

REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1885.

U. S. COAST AND GEODETIC SURVEY OFFICE,  
Washington, June 30, 1885.

SIR: I respectfully submit herewith the annual report of the receipt and registry in the archives of all original and duplicate records and computations, original topographic and hydrographic sheets, and specimens of sea-bottom, turned into the Office during the fiscal year ending June 30, 1885. Also a report relating to the Library.

I.—*Records and Computations.*

## GEODETIC WORK.

	Number of volumes.			
	Original.	Duplicate.	Computations.	Total.
Observations of Horizontal Angles .....	147	115	.....	262
Observations of Vertical Angles .....	23	20	.....	43
Descriptions of Stations .....	16	11	.....	27
Measurement of Bases .....	5	2	.....	7
Spirit-leveling .....	49	44	.....	93
Geodetic Miscellany .....	22	20	.....	42
Computations .....	.....	.....	98	98
Total .....	.....	.....	.....	572

## ASTRONOMICAL WORK.

Observations for Latitude .....	7	2	.....	9
Observations for Longitude .....	1	.....	.....	1
Observations for Time .....	12	7	.....	19
Observations for Azimuth .....	9	2	.....	11
Astronomical Miscellany .....	3	.....	.....	3
Computations .....	.....	.....	37	37
Total .....	.....	.....	.....	80

## MAGNETIC WORK.

Observations of Terrestrial Magnetism .....	94	30	.....	124
Computations .....	.....	.....	15	15
Total .....	.....	.....	.....	139

## HYDROGRAPHIC WORK.

Observations for Soundings .....	257	121	.....	378
Observations of Angles .....	37	25	.....	62
Descriptions of Hydrographic Signals .....	5	.....	.....	5
Specimens of Sea-bottom .....	164	.....	.....	164
Tidal Observations .....	88	54	.....	142
Total .....	.....	.....	.....	751

II.—*Topographic and Hydrographic Surveys.*

## TOPOGRAPHIC WORK.

	Number of sheets.		Number of sheets.
Nestucca Bay and River, Oreg. ....	1	Cherrystone Inlet, Va. ....	1
Route of proposed Cape Cod Ship Canal, Mass. ....	1	Walla Walla River, &c., W. T. ....	2
New London and Vicinity, Conn. ....	1	Fisherman's Bay to Walla Walla River, W. T. ....	1
Hereford Inlet, N. J. ....	1	Total .....	10
Rondout and Harbor, N. Y. ....	2		

## HYDROGRAPHIC WORK.

	Number of sheets.		Number of sheets.
Head of Narragangus Bay, Me .....	2	Nestucca Bay, Oreg.....	1
Shelter Island Sound, N. Y.....	1	Entrance Siuslaw River, Oreg.....	1
Little Neck Bay, N. Y.....	1	Gray's Harbor, Wash. Ter.....	2
Indian River, Fla.....	2	Long Island Sound, N. Y.....	3
Calcasieu Pass, La.....	1	West Coast of Florida.....	4
Monomoy Passage, Mass.....	1	Anclote River, Fla.....	1
Mud Hole Channel, Me.....	1	Lemon Bay, Fla.....	2
Black Rock Harbor, Conn.....	1	Hydrography of Louisiana and Texas.....	3
Hydrography off coast of Maine.....	1	Sabine Pass, Tex.....	1
Fisher's Island Sound, Conn.....	2	Guadalupe Island, Pacific Ocean.....	1
Approaches to New York Harbor.....	2	Temperature sections Gulf of Mexico.....	5
South Branch Elizabeth River, Va.....	2	Gedney and Swash Channels, N. Y.....	1
North River and Coanlock Cut, N. C.....	1	Stephen's Pass and Lynn Canal, Alaska.....	2
Examination Diamond Reef, N. Y.....	1	Chapin Point to Hatchet Point, L. I. Sound.....	3
Lower Delaware Bay, Del.....	1	Jupiter River and Inlet, Fla.....	2
Black Bay, Va. and N. C.....	1	Lakes Bocca Ratone and Wyman, Fla.....	2
Deep-sea Soundings East Bahama Banks.....	1	Pecho Point to Point Buchan, Cal.....	2
Grand Pass, La.....	1		
Pacific Coast, Cal.....	2	Total.....	61

The foregoing exhibit shows that there were registered in the archives during the past fiscal year 572 volumes of geodetic observations and computations; 80 volumes astronomical observations and computations; 139 volumes magnetic observations and computations; 751 volumes hydrographic observations and specimens of sea-bottom; 10 original topographic sheets, and 61 original hydrographic sheets—making a total in volumes, specimens, and sheets combined of 1,613.

On account of the absence of the regularly appointed Librarian by reason of severe illness, no full record was kept of the number of volumes received in the Library previous to December 19.

Since that date, however, an accurate registry has been made of all publications received, and they have been classified and arranged in their respective places. In all, including unbound and bound works, 477 volumes have been entered on the register.

There were prepared and sent out for binding 139 volumes, all of which were returned neatly and durably bound.

During the year many strayed books were recovered and returned. The entire library was rearranged, and a catalogue made, copies of which were furnished the Superintendent and Assistant in charge of Office.

The present condition of the Library, though susceptible of further improvement, is generally considered as being somewhat better than in years past.

The number of volumes taken out since December 10th is eight hundred and twenty-seven. A careful record has been kept of all such books, and their present whereabouts is accurately known.

Respectfully submitted.

Mr. B. A. COLONNA,  
Assistant in charge of Office.

T. D. REED,  
Custodian pro tem.

## REPORT OF WORK DONE IN THE INSTRUMENT DIVISION DURING THE YEAR ENDING JUNE 30, 1885.

COAST AND GEODETIC SURVEY OFFICE,  
Washington, September 1, 1885.

DEAR SIR: I have the honor to submit the following report of the Instrument Division for the fiscal year ending June 30, 1885.

This report has been compiled from such data as were available, chiefly from the monthly reports, as the former Chief of the Division, who was in charge during the whole year, has been removed and is no longer connected with the office.

As heretofore the work of the Division has consisted mainly of repairs and readjustment of instruments turned in by the various field parties. Numerous old instruments have been improved, remodeled, and in some cases entirely reconstructed, and some new instruments, mainly minor ones, have been manufactured. The bulk of the new instruments required to meet the demand of the Survey have been purchased, as the manufacturing facilities of the office are limited and the force employed small.

All instruments returned from the field have been carefully examined and such repairs as were evidently needed and such improvements and alterations as were recommended by the field assistants have been made. Such parts as had become worn or broken were replaced and the instruments put in thorough order for future use.

The keeping of the records and the correspondence relating to the receiving and forwarding of instruments, &c., has also been attended to.

Mr. G. N. Saegmuller, when chief of the Division, supervised all the operations, and has personally attended to the regratuation of circles for theodolites and vertical circles and the limbs of sextants, &c., and the force of the instrument shop, viz, Messrs. John Clark, E. Eshleman, P. Vierbuchen, L. Fischer, and S. Kearney, have satisfactorily performed the duties assigned them.

Yours, respectfully,

ANDREW BRAID,

*Assistant.*

Mr. B. A. COLONNA,  
*Assistant in charge of Office.*

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REPORT OF THE OFFICE OF CONSTRUCTION OF STANDARD WEIGHTS AND MEASURES FOR THE  
FISCAL YEAR ENDING JUNE 30, 1885.

U. S. COAST AND GEODETIC SURVEY,  
*Office of Construction of Standard Weights and Measures, August 17, 1885.*

DEAR SIR: At your request I herewith respectfully submit a report of work done by those employed in the Office of Construction of Standard Weights and Measures for the fiscal year ending June 30, 1885.

James J. Clark, Adjuster, was detailed for duty at New Orleans, La., in care of the Coast and Geodetic Survey exhibit, and was consequently absent from this office from the 1st of December, 1884, till the 15th of June, 1885. The remaining portion of the fiscal year he was engaged in grinding six steel meters to length; compared yard of Yard and Meter No. 1 with British Bronze Yard No. 11; compared a set of weights and measures for New York City, and prepared the Weights and Measures exhibit for the New Orleans Exposition, and also determined the value of the abutting screw belonging to the Saxton Pyrometer No. 3. For a short time he was engaged in adjusting weights for Wyoming Territory, and attended to some of the official correspondence.

E. B. Lefavour, Verifier, was engaged in examining test-floats for specific gravity above 1,000, and tested salinometers; made computations of comparisons of decimeters on glass meter No. 1, also of yards Nos. 57 and 58, and glass meter No. 1 with brass meter No. 49; also computed Mr. Chapman's comparison of a pendulum with meter B; verified a set of weights for New York City; investigated expansion and point of maximum density of sea-water; investigated Densimeters for liquids heavier than water and tested evaporation and effect of meniscus; recorded observations for Mr. Chapman in the pendulum comparisons; adjusted two sets of brass weights for Washington Territory; verified a set of coin weights and set of grain weights for the Mint Bureau; adjusted two balances made by Fairbanks & Co. for Wyoming Territory; compared Yard of Yard and Meter brass bar No. 1 with British Bronze Yard No. 11; also determined the value of the United States Platinum Kilogramme (Arago), and attended to most of the correspondence.

D. C. Chapman, Mechanician, compared the Ohio State Yard with the standard; made ten sets of silver metric weights, six brass 25 and 50 grain weights; compared yard of Yard and Meter brass bar No. 1 with British Bronze Standard No. 11; compared two pendulums with meter B

under the direction of Assistant C. S. Peirce; compared glass meter No. 1 with brass meter No. 49; compared glass decimeters Nos. 3 and 5 with each of the decimeters on glass meter No. 1; adjusted a set of capacity measures for New York City; compared the pendulum returned from the Greely Expedition with meter B; compared yard and foot scale of beam compass for the Washington Navy-Yard; adjusted two sets of capacity measures made by Troemner and Fairbanks, respectively, for Wyoming Territory; compared meter 49 with meter B; made set of coin weights, also set of grain weights for the Mint Bureau, and cleaned and made some new work for the two large balances belonging to the State of New Jersey, damaged by fire at the burning of the Capitol at Trenton.

Yours, respectfully,

JAS. J. CLARK,  
*Adjuster and in Charge of Shop.*

B. A. COLONNA,  
*Acting Superintendent Weights and Measures.*

## APPENDIX NO. 5.

REPORT OF THE HYDROGRAPHIC INSPECTOR FOR THE YEAR ENDING JUNE 30, 1885.

U. S. COAST AND GEODETIC SURVEY OFFICE,

Washington, July 15, 1885.

DEAR SIR: I have the honor to make the following statement in relation to the branch of the Survey with which I have been connected for the past eight years, and of which I have had charge for nearly five years. This will constitute the annual report for the fiscal year ending June 30, 1885, and being my last I may be pardoned for touching on some topics which may seem foreign to the subject-matter.

The beginning of the fiscal year found most of the hydrographic parties preparing for work, which could not commence until after July 1, as has been usually the case during the past seven years with the limited appropriations made by Congress. As I have mentioned in previous reports, to get the most economical results, hydrographic work should begin on the Northern Coast as early as May 1, and can continue, as a rule, until the middle of October or 1st of November. The expenses of refitting the vessels and the principal items for keeping the parties at work are about the same for a long as a short season. It is, therefore, evident that with funds available for the months of July, August, and September only, the season is shortened about 50 per cent., and as the weather during September is generally unsettled, and a portion of July must be consumed in getting the vessels to their stations, the best portion of the season is lost by the delay.

In view of the apparent strong disinclination of Congress to increase the appropriations for party expenses, I would urge that a sufficient amount be retained out of the allotments for surveys on the Northern Coast for work during the last two months of each fiscal year so that it may be made continuous during the summer. I think this policy is particularly applicable to the resurvey of Long Island Sound, and it was with this object in view that I recommended the scheme approved by you for the present season. With only one schooner party (Lieut. S. C. Paine's, on the schooner *Ready*) on that work, but a small portion of the appropriation will be required this summer, and if sufficient is available next spring to put two schooners and one steamer on the survey, and for them to be allowed to continue under the appropriation for the fiscal year 1887, I anticipate the completion of the resurvey of Long Island Sound during the next fiscal year.

During the summer of 1884 there was engaged on the hydrography of the coast of Maine the schooner *Eagre*, with a party under charge of Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey.

A scheme which included some special examinations on this coast was prepared for the hydrographic party on board the steamer *Blake*, under charge of Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey. Owing, however, to a delay in the construction of two new boilers for this vessel at Baltimore, the party did not get to work in time to take it up. Lieutenant-Commander Brownson was enabled, however, to make some important examinations in Vineyard Sound, Narragansett Bay, and Long Island Sound, which are specially mentioned in his report to you.

During the same period the schooner *Palinurus*, with a hydrographic party under charge of

Lieut. W. G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, was engaged upon the resurvey of Long Island Sound. A larger hydrographic force than this was not necessary, as the hydrographic surveys were, at that time, well in advance of the topography, and could be prosecuted to better advantage after the points on which to base the work had been furnished by the civil assistants.

A small party on board the schooner *Ready* was sent into Long Island Sound under charge of Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, and made some special examinations, the small expense of the party being not much more to the survey than if the vessel had been laid up with her crew on broad. Later this party located a rock in Narragansett Bay, and still later made a survey of the shoals extending off Cape Henry, Va., upon which the U. S. S. *Ossipee* had struck, and which had been reported as of greater area than the published charts gave. The general contours were found to be about the same as given from the survey of 1855, and it appeared that the vessel when aground was on a shoal distinctly marked on the charts with 12 feet of water upon it.

The result of the season's work is detailed in the report made to you by the chief of party.

New York Harbor being a place of so much importance, and the changes on its bar, though slight, requiring frequent examinations to keep the mariner supplied with the latest information, it has been my endeavor to give some attention to it each year.

Since the complete resurvey of the bar made by Lieut. Commander E. B. Thomas, U. S. N., Assistant Coast and Geodetic Survey, in 1882, Congress has made no allowance until the present year for such work. In the summer of 1883, the schooner *Drift* having returned from work on the Southern Coast late in the season, and it being very desirable to keep this party intact for the winter's work, Lieut. J. C. Fremont, U. S. N., Assistant Coast and Geodetic Survey, the chief of party, was assigned to this field and obtained data for correcting the charts. Likewise, in 1884, considerable data were obtained for this purpose.

The steamer *Bache*, by reason of requiring new boilers, was left out of the general scheme for work during the summer season of 1884, but the perfectly organized party on board that vessel, as a matter of good public policy retained in the Survey on their naval pay, was used for this purpose. The chief of party, Lieut. H. B. Mansfield, U. S. N., Assistant Coast and Geodetic Survey, in anticipation of an assignment to a regular naval cruiser, was allowed leave, and I assumed the general charge of an examination of the main Ship and Swash Channels, which was well done by the party, under the immediate direction of Ensign J. M. Orchard, U. S. N., Assistant Coast and Geodetic Survey. The expenses of this work were practically little more than if the vessel had remained at the dock awaiting the completion of her boilers, while the results of the work enabled us to give to the public the latest changes, which are so necessary to the pilots of the large steamers entering the port of New York.

The party on board the steamer *Endeavor*, under charge of Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, was engaged upon the resurvey of Delaware Bay at its entrance. The result of the season's work is detailed in the report of Lieutenant Hanus. This completes the list of parties at work during the Summer.

During the Winter the steamer *Bache*, that had been placed under charge of Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, on the detachment of Lieut. H. B. Mansfield, U. S. N., engaged upon an examination of a dredged channel in Mobile Bay; a survey around the Chandeleur Islands, off the coast of Louisiana, and in continuing the hydrography of the West Coast of Florida.

I would state here that the Survey, in losing the services of Lieutenant Mansfield, by reason of his detachment after a four years' tour of duty, lost one of the most valuable hydrographers with whom it has been my good fortune to be associated. Fertile in resources, thorough in his conception of the work, unassuming and pleasant to his subordinates, his party was always ready for his quietly-given instructions, and his abilities were fully equal to the execution of any work intrusted to him. It was only necessary to furnish him with projections and point out the field to be sure of good results. The Survey cannot too soon recall him to its work when his services shall become available.

Lieut. F. H. Crosby, U. S. N., after a short separation from the Survey as one of the officers sent to the relief of the Greely party, was in October again detailed by the Navy Department for the work, and assigned by you to the command of the steamer *Gedney*, in November. During the Winter he, with his party, made a survey of portions of Sabine and Calcasieu Lakes and the coast of Texas generally, as detailed in his report.

Lieut. G. C. Hanus, U. S. N., in charge of the party on board of the steamer *Endeavor*, laid up that vessel at Norfolk, Va., transferred his officers and a sufficient number of men to organize another party to the schooner *Ready*, and proceeded to Charleston, S. C. Here he turned over the *Ready* to the charge of Mr. Eugene Ellicott, Assistant Coast and Geodetic Survey, with the necessary men, and with his own party took charge of the steamer *Arago*, which had been left at that place in anticipation of the work required.

The *Arago's* party ran in the shore-line and made a hydrographic survey of a portion of Stono River and connections through to the Wadmelaw River, and then completed the hydrography of the Saint John's River from Racey Point to Buzzard Island. At the end of the season Lieutenant Hanus's party again joined the *Ready* and under charge of Ensign E. F. Leiper, U. S. N., Assistant Coast and Geodetic Survey, proceeded to New York and rejoined the *Endeavor* at that place, whither Lieutenant Hanus had preceded them to get the vessel ready for the resurvey of New York Harbor.

The steamer *Blake*, which for the past two years had been so ably commanded by Lieut. Commander W. H. Brownson, U. S. N., who was recalled by the Navy Department to regular Naval duties on board of a man-of-war, was fitted out for deep sea current observations, under charge of Lieut. J. E. Pillsbury, U. S. N. It might be proper here for me to place on record my appreciation of Lieut. Commander Brownson's services on the varied work of which he has been placed in charge while commander of the steamers *Gedney* and *Blake*. As, however, at the date of this report, he is again on duty in this office, having been selected by you as my successor in charge of the hydrography of the Coast and Geodetic Survey, it is hardly necessary to state more than that I feel proud of being relieved by an officer of his ability and experience.

No assignment to the command of the steamer *Blake* could, in my opinion, promise such good results as that of Lieut. J. E. Pillsbury, made by you on the detachment of Lieutenant Commander Brownson.

This officer's long experience as the Executive officer of this same vessel during which he frequently was called upon to take the chief command, his long familiarity with charts, his mechanical ingenuity, and his indomitable will cause me to feel the greatest confidence in the future of this scarcely developed but important branch of the Survey, viz, deep-sea currents. The end of the year finds us with most valuable data obtained by him with devices invented by himself during a season off the coast of Florida.

Overcoming difficulties that almost any one else would have regarded insurmountable, he has anchored the steamer *Blake* in the Gulf Stream in four or five hundred fathoms of water, remaining at anchor almost continuously for a complete lunar month, and while his records are not yet completed, the chief of the hydrological branch of the Survey, Prof. H. Mitchell, is enthusiastic in his commendations of the achievements of this party, and being so thoroughly interested in this part of the work, I myself feel that I cannot close this, my last report, without placing on record my strong admiration for the ability of Lieutenant Pillsbury.

Congress having in February passed the appropriation bill containing an item for the resurvey of New York Harbor, which should become immediately available, the office has been taxed to its utmost to obtain the number of proper officers to organize the four parties necessary for the work. Lieutenant Hanus, with his party, on the completion of the work in South Carolina and Florida, became available for one, and Lieut. W. G. Cutler, U. S. N., who had been in charge of the schooner *Palinurus* in the resurvey of Long Island Sound last summer, became available for the chief of a second party, and was placed on the work, again in charge of the *Palinurus*.

Lieut. John M. Hawley, U. S. N., who had served one tour of duty in the Survey before his last cruise in a man-of-war, fulfilled the requirements for a second tour and he was placed in charge of the party on board the schooner *Eagre*.



Lieut. F. S. Carter, U. S. N., having been detailed by the Department for Coast Survey duty was given charge of the schooner *Drift*, which was to be engaged on special current work, it being somewhat new to any one who might be employed.

The scheme prepared by myself and approved by you, made the following disposition of the parties: Lieutenant Hannus with the steamer *Endeavor*, one steam launch, and when necessary the steamer *Daisy* to survey the Entrance and main channels.

Lieutenant Hawley with his party on board the schooner *Eagre*, to which is attached one steam launch, to survey the East River from Governor's Island to the eastward.

Lieutenant Cutler with his party and a steam launch attached to the schooner *Palinurus*, was to survey in the North River, beginning at Governor's Island.

Lieutenant Carter on board the schooner *Drift* with a steam launch was to be associated with a party on board the schooner *Scoresby*, under Assistant H. L. Marindin, who was also supplied with a steam launch, on special current observations at first. Later it is proposed that the *Drift's* party should make current observations outside the entrance of New York Bay.

These parties, with the exception of the *Drift*, were in the field about the first of May, but were somewhat delayed on account of want of topographical data which could not then be furnished; still a very creditable commencement was made up to June 30. Of course this cannot be fully reported before its completion, and naturally comes in the next annual report of the Hydrographic Inspector.

Of the other vessels of the Survey not mentioned before in this report, I have to state that the steamer *Hitchcock* was used by the topographical party under Assistant F. W. Perkins, on the coast of Louisiana.

The barge *Beauty* was used by the topographical party under Assistant C. M. Bache during the summer of 1884 in the interior waters adjacent to the New Jersey coast. The schooner *Quick* was also in service in charge of Assistant Joseph Hergesheimer off the West coast of Florida.

The schooner *Drift*, on which was the hydrographic party under Ensign A. F. Fechteler, U. S. N., was taken to the eastern end of Long Island and used by the topographical party under charge of Assistant Charles Hosmer.

Of the remaining vessels, the steamer *Barataria*, schooners *G. M. Bache*, *Silliman*, and *Research* were laid up during the entire year. All of these vessels have about arrived at a point beyond which repairs become unprofitable, and as the *Bache* and *Silliman* could be used in an emergency, it might be well to retain them on the list, but I would recommend that the *Research* be sold as utterly useless. Through the recommendation of General Samuel B. Holabird, Quartermaster-General U. S. A., a very valuable addition has been made to the fleet of vessels by the transfer of the schooner *Matchless* from the War Department to the Coast and Geodetic Survey. While the transfer is in the nature of a loan, it is probable that the Survey may be possessed for a number of years to come of a very good schooner.

On recommendation of the Light-house Board, a very useful little vessel has been obtained by the transfer of the steamer *Daisy*. The vessel, though quite old, is, it is thought, good for several years' service in inside waters.

What has preceded refers to parties and vessels employed on the Atlantic Coast.

#### PACIFIC COAST.

On the Pacific Coast much difficulty is experienced in executing hydrographic work, for not only is the coast a very difficult one to work upon, but the small appropriations permit only a small portion each year to be spent in actual field-work.

The repair and outfit of the vessels are at a cost almost double what it would be on this coast, while the wages of men are also much higher, as, for instance, a seaman in the Merchant service gets from \$40 to \$70 per month, in other branches of the Government service he receives about \$40, while seamen on board Coast and Geodetic Survey vessels who are shipped on Naval Rolls receive only \$24. This is made up to about \$30 under the allowance for subsistence, but as the appropriations will permit it for only four or five months out of the year it can readily be seen that good

men do not remain in the Survey for any length of time. At the same time this slight increase of pay adds very much to the expense of the work. A larger allotment for the work is the only remedy for this evil.

The passage of the steamer Patterson to the Pacific Coast from New York has been made the subject of a special report to you, but notwithstanding the long passage, under Lieut. R. Clover's able management, she was equipped at San Francisco and was well under way with the work on the Coast of Alaska in the early part of the season. To my mind this is the most important field for surveying which is left to the service, and I cannot too strongly urge the importance of a liberal allotment of money, and the detail of an officer in charge who will have, like the Patterson's present commander, the highest attainments as a surveyor. It is needless to say that the interest I have had in this vessel and her work from its inception, will not lessen after my detachment from the Survey.

The steamer Hassler was engaged with the party under the direction of Lieut. Commander. A. S. Snow, U. S. N. Assistant Coast and Geodetic Survey during the Summer of 1884, on the hydrography of the Straits of Fuca. I cannot commend too highly the energy and intelligence of this officer, whose management of his party has won my strongest approbation and the highest commendations of all members of the Survey who have come in contact with him.

The party on board the steamer McArthur under the charge of Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, has had much to contend with in the field of operations on the coast of California, owing to the small and dangerous character of the harbors.

The meager appropriations have also been a cause of delay, but the chief of party has generally overcome the difficulties and transmitted to the office data, in quality unexcelled by any I have seen from that coast, and equaled by that from very few parties, while the quantity was very creditable indeed for the amount of money allotted for the work.

The schooner Earnest started a very promising season's work in Puget Sound at the commencement of the year, which came to an abrupt termination about the middle of July, by your telegraphic instructions to discontinue the survey on account of lack of appropriations.

The schooner Yukon has been used on topographic work with the party under Assistant J. F. Pratt.

The changes which have taken place among the Naval officers attached to the Survey are indicated in a statement appended to this report. I also append a roster of the officers with their stations on June 30, 1885, a list of names of vessels, their tonnage, &c., in the service of the Survey during the fiscal year, and tabular statements showing the whole number of naval officers on duty at different periods during the year, and the number of men attached to the vessels of the Survey during each quarter of the fiscal year.

#### REPAIRS OF VESSELS.

The repairs and maintenance of the complement of vessels have been made easier this year than usual by the extra allotment in the appropriation made by Congress of \$12,000 for new boilers to the steamer Hassler. I have given in previous reports the general condition of the vessels belonging to the Survey, thus making it unnecessary to do more than summarize the matter here. I will therefore make a table of the amounts expended, and state as follows:

The steamers Hassler, Blake, and Bache have new boilers, and with these large items provided for, the larger vessels of the Survey are believed to be in good condition for service for several years to come. An exception might be made to this in the case of the steamer Blake, which got severely strained while aground on the Saint John's River bar some years ago; and as she has leaked more or less ever since, it may be necessary to make extensive repairs to her hull before long.

I think I can safely say, as a rule, that, excepting the vessels which have been before mentioned as worn out, the vessels of the Survey are in better condition than they were four years ago. It will, however, be a difficult matter to provide for the ordinary wear and tear, particularly now that the Patterson, the largest vessel of the fleet, has been added to the list, on the appropriation passed by Congress for the present fiscal year. The very least that should be estimated for is that

sum to which the appropriation was reduced in 1878, and below which it has never been until the present fiscal year, viz, \$30,000.

#### OFFICE-WORK.

The general office-work has progressed, as usual, to my entire satisfaction, the results being presented in the tabulated records appended to this report, of work done by Messrs. Eugene Willenbücher, W. C. Willenbücher, and F. C. Donn. I may be permitted here, as I am about to sever my connection with the Survey, to submit some remarks in relation to the office of the Hydrographic Inspector, as the matter affects others, and, I believe, the service in general, whose interest alone I have attempted to study during the past eight years of my life.

As I understand, the duties of the Hydrographic Inspector, and which, from my numerous interviews with you, I am led to believe accord with your views, are as follows: He is in charge of the details of all hydrographic work, acting as the chief adviser and executive officer of the Superintendent in hydrography; being responsible to him for the proper execution of all his instructions in relation to hydrographic matters, in the same manner as the Assistant in charge of Office and Topography is responsible to him in matters pertaining to the office and topography. As the Inspector of Hydrography and as in charge of the repairs and maintenance of the vessels of the Survey, his duties are in the field as well as in the office, and among the vessels, with a view to harmonizing all the work of the various hydrographic parties, and to obtain the best results in the repairing of vessels that his experience and the Superintendent's allotments may suggest. He is at the same time in charge of the Hydrographic office, which embraces the Hydrographic Division and the Coast Pilot Division. I have endeavored to carry out this, my interpretation of the Superintendent's various discussions, and I believe that in most cases some benefit has accrued to the harmony of the various branches of the work.

I have been extremely fortunate in having associated with me in the office the best men that have graduated from the Survey under previous assignments. The Coast Pilot work met with a loss when, in December last, Lieut. J. E. Pillsbury was assigned to the command of the steamer Blake, but in the end, the service will gain by his transfer to that command.

Partly from sickness during the past year, more on account of necessary absence from the office on duty, but principally from my sense of what was due the ability of that officer, I have gradually turned all the details of the Hydrographic Division over to Lieut. Jeff. F. Moser, U. S. N., Assistant Coast and Geodetic Survey, in whose hands the very best results possible will be obtained. The Survey will never suffer for want of a strong man (with the most liberal construction that can be placed on the word) for any position in the service as long as he is available for its work.

Mr. Edward H. Wyvill has, as usual, given valuable assistance as my clerk.

I cannot close this, my last report, without expressing my warmest personal obligations for the many acts of courtesy I have received from nearly every member of the Survey, from the Superintendent down, and my interest will ever center in work which to me has so many pleasant associations.

Very respectfully,

C. M. CHESTER,  
*Commander, U. S. Navy,*

*Hydrographic Inspector Coast and Geodetic Survey.*

Prof. J. E. HILGARD,  
*Superintendent U. S. Coast and Geodetic Survey.*

*Hydrographic sheets plotted, verified, and inked during the fiscal year ending June 30, 1885.*

Titles of sheets.	Scale.	Draughtsmen.	Remarks.
<b>ATLANTIC COAST.</b>			
Narraguagus Bay Entrance, Me .....	1-10,000	Eugene Willenbacher .....	Protracted, plotted, and drawn.
Narraguagus River, above Millbridge, Me .....	1-10,000	do .....	Plotted and drawn.
Harrington Bay and River, Me .....	1-10,000	do .....	Do.
Pleasant Bay, Me .....	1-10,000	do .....	Do.
L'Homme Dieu Shoal, &c., Mass .....	1-10,000	F. C. Donn .....	Protracted, plotted, and drawn.
Off Point Judith, R. I. ....	1-10,000	W. C. Willenbacher .....	Plotted and drawn.
Long Island Sound, Race Rock to Plum Gut .....	1-20,000	Eugene Willenbacher .....	Do.
Long Island Sound, Plum Gut to Inlet Point .....	1-20,000	do .....	Do.
Long Island Sound, Inlet Point to Old Landing .....	1-40,000	do .....	Do.
Long Island Sound, Chapin Point to Hatchet Point .....	1-10,000	F. C. Donn .....	Do.
Long Island Sound, Hatchet Point to Cornfield Point .....	1-10,000	do .....	Do.
Long Island Sound, Cornfield Point to Hammonasset Point .....	1-10,000	do .....	Do.
Long Island Sound, Hammonasset Point to Sachem's Head .....	1-10,000	W. C. Willenbacher .....	Do.
Long Island Sound, Sachem's Head to Negro Heads .....	1-10,000	do .....	Do.
Long Island Sound, Chapin Point to Bartlett's Reef .....	1-10,000	Eugene Willenbacher .....	Do.
Dimond Reef, New York Harbor .....	1-5,000	do .....	Protracted, plotted, and drawn.
Gedney and Swash Channels, New York Lower Bay .....	1-10,000	W. C. Willenbacher .....	Do.
Approaches to Delaware Bay .....	1-40,000	Eugene Willenbacher .....	Plotted and drawn.
Delaware Bay, Broadkill to Mispillion Creek .....	1-20,000	do .....	Do.
Delaware Bay, Jones' Creek to Mahon's River .....	1-20,000	W. C. Willenbacher .....	Do.
Back Bay, N. C. ....	1-20,000	do .....	Do.
Jupiter River, Hole Sound, &c., Fla .....	1-5,000	do .....	Do.
Lake Worth, Fla .....	1-40,000	do .....	Do.
Lake Boca Ratone, Hillsboro River, &c., Fla .....	1-10,000	do .....	Do.
Southern part of New River, and Head of Key Biscayne Bay .....	1-20,000	do .....	Do.
South of San Carlos, Fla. (Sheet No. 1) .....	1-40,000	Eugene Willenbacher .....	Do.
South of San Carlos, Fla. (Sheet No. 2) .....	1-40,000	do .....	Do.
Lemon Bay, Fla., Bocilla Inlet to Stump Pass .....	1-20,000	do .....	Do.
Lemon Bay, Fla., Stump Pass to head of Bay .....	1-20,000	do .....	Do.
Saint Joseph's Bay and approaches, Fla. (Sheet No. 1) .....	1-40,000	do .....	Do.
Saint Joseph's Bay and approaches, Fla. (Sheet No. 2) .....	1-40,000	do .....	Do.
Anclote River, Fla .....	1-10,000	do .....	Do.
Grand Pass, Mississippi River, La. ....	1-30,000	W. C. Willenbacher .....	Do.
Off coast of Louisiana and Texas .....	1-80,000	do .....	Do.
Sabine Pass, La. and Tex .....	1-20,000	do .....	Do.
Outer Bar, Galveston Entrance, Tex .....	1-10,000	do .....	Do.
South of Galveston, Tex .....	1-80,000	do .....	Do.
North Atlantic Ocean .....	1-1,200,000	Eugene Willenbacher .....	Do.
<b>PACIFIC COAST.</b>			
Pecho Point to Buchon Point, Cal .....	1-10,000	F. C. Donn .....	Verified, inked, and finished
Buchon Point to Beach Point, Cal .....	1-10,000	do .....	Do.
Beach Point to Moro Rock, Cal .....	1-10,000	do .....	Do.
Moro Rock to Point A, Cal .....	1-10,000	do .....	Do.
Pice House to Castro A, Cal .....	1-10,000	do .....	Do.
Castro A to Breaker Point, Cal .....	1-10,000	do .....	Do.
Breaker Point to northward, Cal .....	1-10,000	do .....	Do.
Salmon Point to Point Cabrillo, Cal .....	1-20,000	do .....	Do.
Point Cabrillo to Brushy Point, Cal .....	1-20,000	do .....	Do.
Nestacca Bay, Oregon .....	1-10,000	W. C. Willenbacher .....	Plotted and drawn.
Siuslaw River Entrance, Oregon .....	1-10,000	do .....	Do.
Gray's Harbor, entrance, W. T .....	1-20,000	do .....	Verified, inked, and finished.
Gray's Harbor, upper part, W. T .....	1-20,000	do .....	Do.
Junction of Stephen's Passage and Lynn Canal, Alaska .....	1-40,000	Eugene Willenbacher .....	Compilation.
Bartlett Cove, Alaska .....	1-20,000	do .....	Do.
Leo Anchorage, Alaska .....	1-20,000	do .....	Do.
Peril Strait, from Point Sulvia to Nismen Point, Alaska .....	1-20,000	do .....	Do.
Inland Passage, Peril Strait to Sitka Harbor .....	1-20,000	do .....	Do.
Wrangell Strait, Alaska .....	1-20,000	do .....	Do.
Southeast Alaska, Revilla Gilego Channel, 12 sheets .....	Various.	F. C. Donn .....	Finishing.

*Hydrographic sheets plotted, verified, and inked during the fiscal year ending June 30, 1885—Cont'd.*

Titles of sheets.	Scale.	Draughtsmen.	Remarks.
MISCELLANEOUS.			
Plan of steamer Hassler .....		F. C. Donn .....	Tracing.
Deep-sea soundings (2,505) .....		Eugene Willenbacher .....	Plotted by latitude and longitude.
Temperature stations (306) .....		do .....	Do.
Current stations (28) .....		do .....	Do.
41 Tracings for Hydrographic parties, Light-House Board, &c .....		W. C. Willenbacher .....	Tracings.
Projects for charts Nos. 714, 715, 727, and 728 .....		Eugene Willenbacher .....	
One projection, Dimond Reef .....	1-5,000	do .....	
Two projections .....	1-20,000	do .....	
Steamer Patterson .....		F. C. Donn .....	Tracing for photolithograph.
Steamer Patterson, curves of stability .....		do .....	Do.
Steamer Patterson, area, moment curves, &c .....		do .....	Do.
Steamer Bache and others .....		do .....	Tracing and comparisons.
Moon's Declination .....		do .....	Copying curves, &c.
Additional hydrography, plotted on four original sheets .....		do .....	Protracted, plotted, and drawn.
Additional hydrography, plotted on 17 original sheets .....		W. C. Willenbacher .....	Do.
Progress sketch, coast of Maine .....	1-10,000	do .....	Drawn.

*Verification and correction of reduced Drawings of Hydrography for fiscal year ending June 30, 1885.*

Catalogue number of Charts.	Title of Charts.	Scale.	Draughtsman.
C	Gulf of Mexico .....	1-1,200,000	Eugene Willenbacher.
14	Cape Canaveral to Fowey Rocks .....	1-400,000	Do.
15	Straits of Florida .....	1-400,000	Do.
16	Key West to Tampa Bay .....	1-400,000	Do.
103	Mount Desert Island, &c .....	1-80,000	Do.
120	New York Bay and Harbor .....	1-80,000	Do.
121	Sandy Hook to Barnegat .....	1-80,000	Do.
140	Albemarle Sound (eastern sheet) .....	1-80,000	Do.
131	Entrance to Chesapeake Bay .....	1-80,000	Do.
147	Coast chart 47 .....	1-80,000	Do.
148	Coast chart 48 .....	1-80,000	Do.
152	Coast chart 52 .....	1-80,000	Do.
153	Winyah Bay to Long Island .....	1-80,000	Do.
175	San Carlos Bay to Lemon Bay .....	1-80,000	Do.
176	Lemon Bay to Tampa Bay .....	1-80,000	Do.
177	Tampa Bay .....	1-80,000	Do.
439	Calibogue Sound and Skull Creek .....	1-80,000	Do.
440	Savannah River and Wassaw Sound .....	1-80,000	Do.
621a	San Francisco Entrance .....	1-80,000	Do.
650	Port Gamble .....	1-20,000	Do.
673	Point Concepcion to San Luis Obispo .....	1-200,000	Do.
710	Revilla Gigedo Channel .....	1-200,000	Do.
712a	Harbors Revilla Gigedo Channel .....	Various.	Do.
714	Wrangell Strait, Port Wrangell, &c .....	1-40,000	Do.
715	Anchorage in Southeast Alaska .....	Various.	Do.
727	Inland passage between Sitka and Hooniah Sound .....	1-40,000	Do.
728	Junction of Stephen's Passage and Lynn Canal .....	1-80,000	Do.

*Charts for which reduced drawings of hydrography were made during the fiscal year ending June 30, 1885.*

Catalogue number of charts.	Title of Charts.	Scale.	Draughtsmen.
A	Cape Sable to Cape Hatteras .....	1-1, 200, 000	Eugene Willenbacher.
B	Cape Hatteras to Key West .....	1-1, 200, 000	Do.
C	Gulf of Mexico .....	1-1, 200, 000	Do.
C	Do .....	1-1, 200, 000	W. C. Willenbacher.
D	Do .....	1-2, 100, 000	Eugene Willenbacher.
10	Cape Henry to Cape Lookout .....	1-400, 000	W. C. Willenbacher.
14	Cape Canaveral to Fowey Rocks .....	1-400, 000	Do.
14	Do .....	1-400, 000	Eugene Willenbacher.
103	Coast chart No. 3 .....	1-80, 000	Do.
103	Do .....	1-80, 000	W. C. Willenbacher.
104	Penobscot Bay .....	1-80, 000	Do.
105	Penobscot Bay to Kennebec Entrance .....	1-80, 000	Do.
106	Kennebec Entrance to Saco River .....	1-80, 000	Do.
112	Monomoy to Block Island (Middle sheet) .....	1-80, 000	F. C. Donn.
113	Monomoy to Block Island (Western sheet) .....	1-80, 000	Do.
113	Monomoy to Block Island (Western sheet) .....	1-80, 000	W. C. Willenbacher.
114	Long Island Sound (Eastern sheet) .....	1-80, 000	Do.
115	Long Island Sound (Middle sheet) .....	1-80, 000	Do.
120	New York Bay and Harbor .....	1-80, 000	Do.
124	Delaware Bay (Lower sheet) .....	1-80, 000	Do.
125	Delaware Bay (Middle sheet) .....	1-80, 000	Do.
137	Cape Henry to Currituck Beach .....	1-80, 000	Do.
142	Pamlico Sound (Sheet No. 1) .....	1-80, 000	Do.
143	Pamlico Sound (Sheet No. 2) .....	1-80, 000	Do.
156	Savannah to Sapelo Island .....	1-80, 000	Eugene Willenbacher.
170	Key West to Rebecca Shoal .....	1-80, 000	W. C. Willenbacher.
307	Blue Hill Bay, &c .....	1-40, 000	Do.
353	Narragansett Bay .....	1-40, 000	Do.
353	Do .....	1-40, 000	F. C. Donn.
362	New Haven Harbor .....	1-20, 000	W. C. Willenbacher.
369	New York Bay and Harbor .....	1-40, 000	Do.
369	New York Entrance .....	1-40, 000	Do.
675	Point Pinos to Bodega Head .....	1-200, 000	Do.
676	San Francisco to Point Arena .....	1-200, 000	Do.
900	Alaska and adjacent Territory .....	1-3, 500, 000	Eugene Willenbacher.

*List of Naval officers attached to Coast and Geodetic Survey during fiscal year ending June 30, 1885.*

Name.	Date attached.	Remarks.	Name.	Date attached.	Remarks.
<b>COMMANDERS.</b>			<b>LIEUTENANTS—Cont'd.</b>		
C. M. Chester .....	Oct. 2, 1877	Still in service.	J. E. Pillsbury .....	July 13, 1882	Still in service.
<b>LIEUTENANT-COMMANDERS.</b>			Jeff. F. Moser .....	Jan. 29, 1884	Do.
A. S. Snow .....	Aug. 1, 1883	Still in service.	Charles F. Forae .....	July 7, 1884	Do.
W. H. Brownson .....	Aug. 11, 1881	Detached December 2, 1884; re-attached June 29, 1885.	J. M. Hawley .....	Mar. 21, 1885	Do.
H. E. Nichols .....	Jan. 22, 1879	Detached July 31, 1884.	G. Blocklinger .....	Jan. 30, 1883	Do.
<b>LIEUTENANTS.</b>			S. C. Paine .....	June 2, 1885	Do.
J. T. Sullivan .....	Nov. 21, 1882		F. H. Crosby .....	Oct. 6, 1884	Do.
H. B. Mansfield .....	Feb. 28, 1881		G. C. Hanus .....	Mar. 20, 1883	Do.
E. D. F. Heald .....	Mar. 23, 1882	Still in service.	F. H. Lefavor .....	Sept. 6, 1882	
Richardson Clover .....	July 26, 1881	Do.	J. C. Fremont .....	May 21, 1881	
E. D. Taussig .....	Apr. 30, 1883	Do.	<b>LIEUTENANTS, JUNIOR GRADE.</b>		
			C. McR. Winslow .....	Aug. 16, 1881	
			George H. Peters .....	June 30, 1885	Still in service.

*List of Naval officers attached to Coast and Geodetic Survey, &c.—Continued.*

Name.	Date attached.	Remarks.	Name.	Date attached.	Remarks.
<b>LIEUTENANTS, JUNIOR GRADE—Cont'd.</b>			<b>LIEUTENANTS, JUNIOR GRADE—Cont'd.</b>		
J. M. Helm .....	Feb. 13, 1885	Still in service.	A. P. Niblack .....	July 2, 1884	Still in service.
W. G. Cutler .....	Mar. 29, 1883	Do.	William Truxton .....	July 3, 1882	Do.
F. S. Carter .....	Apr. 23, 1885	Do.	E. Simpson, jr. ....	Oct. 21, 1882	Do.
<b>ENSIGNS.</b>			J. H. Watters .....	July 7, 1883	Do.
W. McLean .....	July 15, 1884	Still in service.	E. F. Leiper .....	Apr. 26, 1883	Do.
T. D. Griffin .....	May 2, 1883	Do.	M. C. Gorgas .....	Oct. 26, 1882	Do.
F. H. Sherman .....	Oct. 31, 1882	Do.	F. R. Brainard .....	July 20, 1883	Do.
J. M. Orchard .....	Feb. 10, 1882	Do.	T. G. Dewey .....	June 18, 1883	Do.
J. N. Jordan .....	Jan. 25, 1881	Do.	G. R. French .....	May 4, 1883	Do.
J. P. Parker .....	Mar. 5, 1883	Detached September 30, 1884.	F. A. McNutt .....	Oct. 15, 1884	Do.
A. F. Fechteler .....	June 24, 1882	Still in service.	<b>SURGEONS.</b>		
F. M. Brumby .....	Dec. 21, 1882	Do.	W. S. Dixon .....	Apr. 20, 1884	Still in service.
E. E. Wright .....	Apr. 7, 1885	Do.	<b>PASSED ASSISTANT SURGEONS.</b>		
A. W. Dodd .....	Apr. 9, 1885	Do.	F. H. Streets .....	Mar. 19, 1884	Still in service.
Alfred Jeffries .....	July 17, 1882	Detached June 15, 1885.	E. Y. Derr .....	Sept. 7, 1881	Detached September 1, 1884.
W. V. Bronaugh .....	Aug. 12, 1881	Detached November 30, 1884.	F. B. Stephenson .....	Sept. 1, 1884	Still in service.
F. M. Boatwick .....	Sept. 28, 1881	Still in service.	W. H. Rush .....	June 3, 1884	Do.
A. L. Hall .....	May 1, 1883	Do.	<b>ASSISTANT SURGEONS.</b>		
P. J. Werlich .....	Mar. 15, 1884	Do.	H. B. Fitts .....	Jan. 27, 1884	Still in service.
W. L. Burdick .....	Mar. 31, 1884	Do.	<b>PASSED ASSISTANT PAYMASTERS.</b>		
P. B. Bibb .....	Nov. 30, 1882	Detached July 28, 1884.	J. R. Stanton .....	Nov. 1, 1883	Still in service.
W. C. Canfield .....	Sept. 26, 1882	Still in service.	<b>PASSED ASSISTANT ENGINEERS.</b>		
A. G. Rogers .....	Apr. 29, 1885	Do.	H. Main .....	May 29, 1883	Still in service.
W. P. White .....	Feb. 10, 1883	Do.	H. N. Stevenson .....	Mar. 10, 1883	Do.
John H. Shipley .....	Apr. 17, 1885	Do.	G. H. Kearney .....	Oct. 5, 1881	Detached January 1, 1885.
John E. Craven .....	Nov. 28, 1883	Do.	George Cowie, jr. ....	Jan. 1, 1885	Still in service.
J. H. Hetherington .....	June 19, 1883	Do.	N. N. Leitch .....	Jan. 14, 1885	Detached January 19, 1885.
C. C. Marsh .....	May 3, 1884	Do.	R. W. Galt .....	Nov. 26, 1879	Detached November 15, 1884.
C. W. Jungen .....	Aug. 25, 1883	Do.	<b>ASSISTANT ENGINEERS.</b>		
R. P. Schwerin .....	May 3, 1883	Detached July 11, 1884.	William N. Little .....	Nov. 15, 1884	Detached January 13, 1885.
C. S. Ripley .....	May 4, 1885	Still in service.	E. T. Warburton .....	Feb. 24, 1883	Still in service.
W. J. Sears .....	Apr. 28, 1885	Do.	R. I. Reid .....	June 19, 1882	Do.
J. A. Bell .....	Feb. 22, 1885	Do.			
D. P. Menefee .....	July 28, 1883	Do.			
F. W. Kellogg .....	Aug. 23, 1882	Do.			
W. A. Thom .....	Nov. 1, 1884	Do.			
R. O. Bitler .....	Apr. 29, 1885	Do.			
Harry Phelps .....	June 30, 1883	Detached September 30, 1884.			

*List of Naval Officers attached to Coast and Geodetic Survey, June 30, 1885.*

Commander C. M. Chester, Hydrographic Inspector.

Lieut. Commander W. H. Brownson, Coast and Geodetic Survey Office.

Lieut. Jeff. F. Moser, Coast and Geodetic Survey Office.

Lieut. George H. Peters, Coast and Geodetic Survey Office.

Passed Assistant Paymaster J. R. Stanton, Coast and Geodetic Survey Office.

**ATLANTIC AND GULF COASTS.**

*Steamer A. D. Bache* (Atlantic Coast).—Lieut. E. D. F. Heald, Commanding; Ensigns, J. M. Orchard, W. C. Canfield, John E. Craven, and W. J. Sears; Passed Assistant Surgeon, F. B. Stephenson; Passed Assistant Engineer, Herschel Main.

*Steamer G. S. Blake* (Atlantic Coast).—Lieut. John E. Pillsbury, Commanding; Ensigns, A. F. Fechteler, P. J. Werlich, William A. Thom, William Truxton, E. Simpson, jr., and Miles Gorgas; Passed Assistant Surgeon, William H. Rush; Passed Assistant Engineer, George Cowie, jr.

*Schooner Eagle* (Atlantic Coast).—Lieut. John M. Hawley, Commanding; Ensigns, F. H. Sherman, A. W. Dodd, and R. O. Bitler.

*Schooner Ready* (Atlantic Coast).—Lieut. Sumner C. Paine, Commanding; Ensign, T. D. Griffin.

*Steamer Gedney* (Atlantic Coast).—Lieut. Freeman H. Crosby, Commanding; Ensigns, T. M. Brumby, A. L. Hall, John H. Hetherington, F. W. Kellogg, and J. S. Watters; Assistant Surgeon, Henry B. Fitts.

*Steamer Endeavor* (Atlantic Coast).—Lieut. G. C. Hanus, Commanding; Ensigns, Charles S. Ripley, Edward F. Leiper, F. R. Brainard, and George R. French.

*Schooner Palinurus* (Atlantic Coast).—Lieut. William G. Cutler, Commanding; Ensigns, E. M. Wright and A. G. Rogers.

*Schooner Drift* (Atlantic Coast).—Lieut. Fidelio S. Carter, Commanding.

## PACIFIC COAST.

*Steamer Hassler* (Pacific Coast).—Lieut. Commander A. S. Snow, Commanding; Lieut. G. Blocklinger; Ensigns, F. M. Bostwick, W. P. White, J. H. Shipley, and C. W. Jungen; Surgeon, William S. Dixon; Assistant Engineer, E. T. Warburton.

*Steamer Patterson* (Alaska Coast).—Lieut. Richardson Clover, Commanding; Lieut. James M. Helm; Ensigns, W. McLean, C. C. Marsh, D. P. Menefee, A. P. Niblack, and T. G. Dewey; Passed Assistant Surgeon, Thomas H. Streets; Passed Assistant Engineer, H. N. Stevenson.

*Steamer McArthur* (Pacific Coast).—Lieut. Edward D. Taussig, Commanding; Ensigns, William L. Burdick, John A. Bell, and F. A. McNutt; Assistant Engineer, R. I. Reid.

*Schooner Earnest* (Pacific Coast).—Lieut. Charles T. Forse, Commanding; Ensign, J. N. Jordan.

*Names of vessels, their tonnage, &c., in the service of the Coast and Geodetic Survey, during the fiscal year ending June 30, 1885.*

No.	Name of vessel.	Tonnage.	Complement of—	
			Officers.	Men.
1	Steamer Carlile P. Patterson .....	453	9	36
2	Steamer Hassler .....	243	9	34
3	Steamer Blake .....	218	8	36
4	Steamer Bache .....	186	7	33
5	Steamer Gedney .....	133	7	29
6	Steamer McArthur .....	112	7	29
7	Steamer Endeavor .....	105	5	17
8	Steamer Hitchcock (civilian party) .....	88		
9	Steamer Barataria (laid up) .....	50		
10	Steamer Arago .....	38	3	15
11	Steamer Daisy .....	44		
1	Schooner Eagle .....	202	4	18
2	Schooner Drift .....	87	4	14
3	Schooner Earnest .....	80	2	12
4	Schooner Ready .....	80	3	14
5	Schooner Yukon (civilian party) .....	78		
6	Schooner Research (laid up) .....	76		
7	Schooner Palinurus .....	76	3	14
8	Schooner Silliman (laid up) .....	72		
9	Schooner Scoresby (civilian party) .....	72		
10	Schooner Matchless (laid up) .....			
11	Schooner G. M. Bache (laid up) .....	46		
12	Schooner Quick (civilian party) .....	38		
1	Sloop Kincheloe (civilian party) .....	30		
1	Barge Beauty (civilian party) .....	28		

## RECAPITULATION.

Whole number of vessels:	
Steamers .....	11
Schooners .....	12
Sloops .....	1
Barges .....	1
Total .....	25
Number of vessels in active service .....	19



This complement does not represent the actual number of officers or of men in the Survey during the year, owing to the fact that some vessels were employed only a part of the time.

Average number of officers for the year ..... 54

Average number of men for the year ..... 280

See tabular statements appended showing actual number of officers attached to the several vessels in service and number of officers on other duty at different periods during the fiscal year; also the number of men actually in service at the end of each quarter of the fiscal year, with the names of the vessels in which they were serving.

*Number of naval officers attached to Coast and Geodetic Survey vessels for fiscal year ending June 30, 1885.*

Name of vessel.	September 30, 1884.	March 31, 1885.	Name of vessel.	September 30, 1884.	March 31, 1885.
Steamer Blake .....	7	9	Steamer McArthur .....	3	6
Steamer Bache .....	4	8	Schooner Eagle .....	4	2
Steamer Gedney .....	2	7	Schooner Ready .....	3	3
Steamer Endeavor .....	4		Schooner Palinurus .....	3	1
Steamer Arago .....		1	Schooner Earnest .....	2	1
Steamer C. P. Patterson ..	9	9	Coast Survey Office .....	3	3
Steamer Hassler .....	7	7	Total .....	51	57

Average number, 51.

*Number of men attached to Coast and Geodetic Survey vessels for fiscal year ending June 30, 1885.*

Name of vessel.	For quarter ending—			
	September 30, 1884.	December 31, 1884.	March 31, 1885.	June 30, 1885.
Steamer Blake .....	35	35	39	36
Steamer Bache .....	31	31	33	28
Steamer Gedney .....	24	27	27	25
Steamer Endeavor .....	17	17	8	20
Steamer Arago .....			14	
Steamer Daisy .....				8
Steamer Hassler .....	34	33	33	31
Steamer C. P. Patterson ..	38	39	37	38
Steamer McArthur .....	28	27	29	29
Schooner Eagle .....	19	8	12	17
Schooner Palinurus .....	15	5	15	15
Schooner Drift .....			9	14
Schooner Ready .....	15	14		16
Schooner Earnest .....	8	8	8	15
Vessels laid up .....	15	16	11	14
Total .....	279	260	275	306

Average number, 280.

## APPENDIX No. 6.

### THE GEOGRAPHICAL DISTRIBUTION AND SECULAR VARIATION OF THE MAGNETIC DIP AND INTENSITY IN THE UNITED STATES.

By CHARLES A. SCHOTT, Assistant.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY.

October 24, 1885.

DEAR SIR: Accompanying this I submit a paper entitled "Magnetic dip and intensity, with their secular variation and geographical distribution in the United States," with three maps and three plates, intended to form Appendix No. 6, report for fiscal year 1884-'85.

This paper constitutes the concluding part of the magnetic researches lately undertaken by the Survey, those relating to the declination having been published in Appendices 12 and 13, report for 1882; the epoch of reduction being the same, viz, January, 1885.

Upon first taking up the subject, over thirty years ago, it became apparent that the time had not arrived for a profitable discussion of the very meager material then on hand. I have, therefore, confined my labors in the interval to the collection of observations, deferring discussion to a later time.

In the general table of magnetic dips and intensities now presented, there are, systematically arranged, 2000 dip observations and more than 1500 horizontal intensity observations. The order is by States and Territories, and for each division by latitude of station, and for each place the observations are given in chronological succession. This table, containing a general collection of all observed values (known to me) from the earliest times, will, it is supposed, be of more permanent value than the additional information it contains relating to the epoch 1885.

The discussion of the secular variation of the dip resulted in a more or less complete knowledge of the law of change during the last sixty years, and enabled me to recognize and delineate a belt of present "no change" with increasing dip on one side and decreasing dip on the other. A similar feature was recognized in the discussion of the secular variation of the horizontal intensity, the absolute measures of which hardly extend back half a century.

The above results are laid down on three diagrams, and the details of the present geographical distribution over the area of the United States are presented on three maps, on a scale adapted to the density of distribution of the observations and the intricacies of the isomagnetic curves.

Yours, respectfully,

CHAS. A. SCHOTT,  
*Assistant.*

Mr. B. A. COLONNA,  
*Assistant, in Charge Office and Topography.*

H. Ex. 18—17

129

COLLECTION AND DISCUSSION OF RESULTS FOR DIP AND INTENSITY OF THE EARTH'S MAGNETIC FORCE WITHIN AND NEAR THE LIMITS OF THE UNITED STATES, WITH THEIR GEOGRAPHICAL DISTRIBUTION AND SECULAR VARIATION AT THE EPOCH 1885.0, AS DEDUCED FROM OBSERVATIONS BETWEEN THE EARLIEST AND THE PRESENT TIME.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE.

September 11, 1885.

#### INTRODUCTION.

In the annual reports of the Coast and Geodetic Survey for the fiscal year 1880-'81 and the fiscal year 1881-'82 the subject of terrestrial magnetism, and in particular that part of it relating to the declination, has been brought to the latest practicable state of forwardness, as far as it relates to the operations of the Survey, and seems nearly exhaustive of the material so far accumulated by observers. It appeared, therefore, timely to direct attention to the state of our knowledge of the magnetic dip and intensity. Indeed, for years past it has seemed to me desirable to resume their discussion, which was abandoned nearly thirty years ago. During this time the demand for practical information about the magnetic dip and intensity has increased, mainly in consequence of the necessity of giving closer attention to the deviation and adjustment of the compass in iron and steel ships, though in this connection no high degree of accuracy of numerical values was required. The observations accumulated since 1855 gave a better prospect of obtaining clearer and more precise information respecting the law of the secular change of the dip and of the intensity, and, as will be seen in the sequel, this brief period embraced the (unsuspected) occurrence of a secondary maximum in the variation of the dip, as well as of a minimum in the variation of the horizontal component of the intensity.

But the principal object in view in making the present investigation was to advance our knowledge in this department of terrestrial physics by completing the work already undertaken by the Survey and bringing the results up to date. It was, therefore, indispensable first to prepare as complete a collection of data as could be brought together, to scrutinize and arrange them, and finally to discuss and present the results.

#### PART I.

In the general collection of data, as far as they were known or accessible to me, there are brought together in systematic form all observed dips and intensities within our boundaries from the earliest to the present time. The observations for dip and for horizontal and total intensities are arranged alphabetically, according to the present political divisions by States and Territories, and within each of these subdivisions the arrangement is by latitude, and for each station the several results, if any, are placed in strictly chronological order. To cover such adjacent regions outside of our boundaries as seemed desirable for the purpose of constructing isomagnetic charts, several geographical divisions are added to the collection. This arrangement then differs but in one particular from that adopted in 1882 in the case of the declinations, viz, it unites in one table *all* results, whereas the declinations, on account of their greater number, were more conveniently presented in *two* tables, the last containing the chronological arrangement for each place in connection with the discussion of the secular change.

No observations made at sea were admitted in the collection, these being in general less accurate, for want of complete elimination of the effect of local attraction on board ship. There are, however, a few results included obtained on the frozen ocean off the coast of Alaska, and it is only in this Territory that the question of the advisability of taking in observations made at sea could arise. Many such additional observations, if needed, might be taken from the Philosophical Transactions of the Royal Society for 1872, Contributions to Terrestrial Magnetism, No. XIII, by General Sir Edward Sabine.

The table provides for dips ( $\theta$ ), horizontal intensities ( $H$ ), and total intensities ( $F$ ), but not for vertical intensities ( $V$ ), as the latter are not subject to direct instrumental measure, whereas  $H$ , as well as  $F$ , may have been instrumentally determined, though where the results are given in absolute measure,  $H$  alone could have been directly so measured. In consequence of the mutual relations

of  $\theta$ ,  $H$ ,  $V$ ,  $F$ , when any two of these quantities are given by observation the other two may be found. The analytical dependence between the tabular values  $\theta$ ,  $H$ ,  $F$  may not always appear numerically strictly satisfied, for the reason that each of the three quantities results directly from independent observations, and thus necessarily is subject to error; hence the relation  $H = F \cos \theta$  would be but partly satisfied, but when strictly satisfied by the tabular values it indicates that two only of the three values entering were derived from direct observation. Unless access can be had to the original records or discussion, it is not always possible to know which of these quantities were the original ones, though in refined work and in lower magnetic latitudes generally  $\theta$  and  $H$ , and in the higher magnetic latitudes  $\theta$  and  $F$ , will be found in the majority of cases to have been the fundamental, and  $F$  and  $H$ , respectively, the derived quantities; and there are even a few instances where  $\theta$  is derived from relative measures of  $F$  and  $H$ . No attempt was made to fill in by computation the third quantity from the other two values, but the quantity was inserted when found already computed, and in some cases when specially needed. If the vertical component of the intensity is required, it may be computed from one of the following relations:

$$V = F \sin \theta = H \tan \theta = \sqrt{F^2 - H^2}$$

further we have also the simple relations:

$F = H \sec \theta$ $H = F \cos \theta$ $\frac{H}{F} = \cos \theta$	$dF = \sec \theta dH + F \tan \theta d\theta$ $dH = -F \sin \theta d\theta + \cos \theta dF$ $d\theta = -\frac{dH}{F \sin \theta} + \frac{\cot \theta}{F} dF$ $dV = \operatorname{cosec} \theta dF - \cot \theta dH$ $dV = H \sec^2 \theta d\theta + \tan \theta dH$	$\frac{dF}{F} = \frac{dH}{H} + \tan \theta d\theta$ $\frac{dF}{F} = \cos^2 \theta \frac{dH}{H} + \sin^2 \theta \frac{dV}{V}$ $\frac{dV}{V} = \operatorname{cosec}^2 \theta \frac{dF}{F} - \cot^2 \theta \frac{dH}{H}$ $\frac{dV}{V} = \frac{d\theta}{\sin \theta \cos \theta} + \frac{dH}{H}$
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All relative intensities were converted into absolute measures and expressed in terms of the English units—the foot, the grain, and the second of mean time; results expressed in Gaussian or French units, and in the British Association or centimetre-gramme-second (or C. G. S.) units, were all changed to conform to the majority of cases, in which the English units were employed.

On the maps which show the distribution of the horizontal and total intensities, referred to the epoch 1885.0, the centimetre-gramme-second (or C. G. S.) units are also introduced. (See figures within parentheses.)

#### EXPLANATION OF THE GENERAL TABLE.

The general table of observed magnetic dips and intensities is subdivided and arranged by States, Territories, and adjacent foreign regions. Their number in each of these divisions is as follows:

Number.	States and Territories.	Number of results.		Number.	States and Territories.	Number of results.	
		Dips.	Horizontal forces.*			Dips.	Horizontal forces.*
1	Alabama.	9	9	9	Delaware.	9	8
2	Alaska Territory.	72	39	10	District of Columbia.	57	41
3	Arizona Territory.	69	34	11	Florida.	28	26
4	Arkansas.	0	0	12	Georgia.	21	22
5	California.	70	59	13	Idaho Territory.	7	8
6	Colorado.	9	9	14	Illinois.	33	16
7	Connecticut.	31	28	15	Indiana.	19	16
8	Dakota Territory.	4	4	16	Indian Territory.	3	3

\* Directly or indirectly given.

Number.	States and Territories.	Number of results.		Number.	States and Territories.	Number of results.	
		Dips.	Horizontal forces.*			Dips.	Horizontal forces.*
17	Iowa.	28	25	40	South Carolina.	7	10
18	Kansas.	11	7	41	Tennessee.	19	18
19	Kentucky.	25	21	42	Texas.	18	11
20	Louisiana.	25	19	43	Utah Territory.	18	13
21	Maine.	76	51	44	Vermont.	13	11
22	Maryland.	40	35	45	Virginia.	37	36
23	Massachusetts.	76	55	46	Washington Territory.	37	39
24	Michigan.	65	49	47	West Virginia.	9	9
25	Minnesota.	13	13	48	Wisconsin.	24	19
26	Mississippi.	10	11	49	Wyoming Territory.	20	12
27	Missouri.	84	82				
28	Montana Territory.	7	7	50	Dominion of Canada, to longitude 75° W.	55	40
29	Nebraska.	15	8	51	Dominion of Canada, between longitudes 75° and 90° W.	97	92
30	Nevada.	27	19	52	British Possessions, Northwestern America, south of latitude 51°.	69	40
31	New Hampshire.	25	16	53	British Possessions, Northwestern America, north of latitude 51°.	74	40
32	New Jersey.	36	32	54	West India Islands and Bermudas.	52	30
33	New Mexico.	18	5	55	Mexico and Central America.	88	71
34	New York.	122	98	56	Eastern Siberia.	31	15
35	North Carolina.	18	16				
36	Ohio.	72	37				
37	Oregon.	15	14				
38	Pennsylvania.	70	66				
39	Rhode Island.	12	9				
					Total number.	1999	1523

\* Directly or indirectly given.

The geographical divisions (50 to 56) comprise only such foreign parts contiguous to the United States which it appeared desirable to include for the study of the secular change of the magnetic elements or which would be useful in the construction of isomagnetic charts. Considerable labor was involved by the adoption of these divisions, since many of the States and Territories had no separate existence at the time when the earlier observations were recorded.

In each division the arrangement of the stations is by latitude, which offers advantages due to the circumstance that the isoclinic and isodynamic curves intersect the parallels of latitude generally at an acute angle.

The latitudes and longitudes as given in the original publications were scrutinized and corrected when possible, and in particular the telegraphic longitudes were introduced either directly or differentially; nevertheless there are many places whose positions are still imperfectly known for want of proper surveys. To avoid the large number of minus signs the longitude columns are headed "West longitude," except for the divisions Alaska and Eastern Siberia, where the west longitudes have been distinguished by a —, the east longitudes by a + sign, in conformity with the decision of the International Meridian Conference held at Washington in October, 1884.

A few dips, originally recorded in centesimal degrees, were changed to the usual division of the quadrant. For the change of relative into absolute measure of intensity the data will generally be found in the original publications, or else they were subsequently added and referred to in the last column of the table. Many of the intensities of the Canadian stations were expressed in relative measure, and it was a fortunate circumstance that Sir J. H. Lefroy's work, "Diary of a Magnetic Survey of a Portion of the Dominion of Canada, &c., in the years 1842-'44," London, 1883, appeared in

time to be used in this paper. Dips and absolute intensities were transcribed from this volume unaltered in preference to any values formerly given. The results of the extensive series of observations of relative intensities by Dr. J. Locke, of Cincinnati, were taken from Art. XI of the Trans. of the Amer. Phil. Soc., 1846. "Observations made in the years 1838-'39-'40-'41-'42-'43 to determine the magnetic dip and the intensity of magnetic force in several parts of the United States, April, 1844." To these observations those of 1844 were afterwards added, which afforded additional means for the introduction of absolute values. The whole series was published by Sir E. Sabine in the Phil. Trans. Roy. Soc. for the year 1846, Part III. He finds from a series of comparisons at several stations that the total force in 1844 at Cincinnati, Dr. Locke's base station, was well represented by the number 1.795 of the arbitrary scale, in which Toronto was 1.836 in that year. At Toronto in 1844 the total force  $F$  was determined at 13.90 (hence with the observed dip we have also  $H=3.540$ ), hence for Cincinnati  $F=13.59$ . I have recomputed Dr. Locke's intensity observations after making a small allowance for secular diminution of  $H$  between the years 1838 and 1844, putting for Cincinnati  $H_{1838}=4.560$  and  $H_{1844}=4.548$ , the latter value corresponding to the value of  $H$  given for that year for Toronto.

For the conversion of the relative measures (in Phil. Trans. Roy. Soc., 1838) by Captain Sir Everard Home in the West Indies and other localities during 1834-'35-'36-'37, I have used for his initial station, Plymouth, England, the values  $\theta_{1835}=69^{\circ} 20'$ ,  $H_{1835}=3.639$  and  $F_{1835}=10.31$ .

For the conversion into absolute measure of D. Douglas' series on the Western coast between 1830 and 1833, I have used for his base stations Fort Vancouver,  $H_{1830}=4.442$ ; Monterey,  $H_{1831}=5.629$ ; and London,  $F_{1833}=10.388$ .

The relative total intensities by Captain Whipple and Lieutenant Ives in 1850-'53-'54 are given in absolute measure by means of the base station, Cambridge, Mass.,  $F_{1853}=13.37$ .

In those cases where Washington was used as a base station, the annual values of  $H$  and  $F$  will be found in Part III of this paper in connection with the secular variation of the intensity, and it may also be remarked that at this station we have a direct comparison of instrumental constants as determined at Kew, England, and at Washington through the observations made here by Dr. Thorpe, who visited the United States in 1878 on the occasion of the solar eclipse of that year. The tabular results as observed and computed show a satisfactory accord.

Some further information respecting the change from relative to absolute intensities for the earlier series of observations will be found in Coast Survey Report for 1861, Appendix No. 22, and we have only to remark that all such results prior to the time, 1833-1836, when Gauss showed how to express the magnetic force in absolute measure and Weber constructed his portable magnetometer, are necessarily of inferior accuracy, and in part conjectural, and it should also be remembered that in early times observers like Humboldt, Franklin, Sabine, and others, down to 1823, measured differentially the earth's magnetic force by counting the oscillations of the dipping-needle—a method long since abandoned on account of its inferiority. Lloyd's statical method, especially when it combines gravity and magnetic deflections, is capable of excellent results, as shown, for instance, by Lieutenant Ackley's observations in the West Indies in 1879-'80, when that method was employed in connection with oscillations of the horizontal needle for the purpose of direct comparisons.

The tabular results in general take no cognizance of the diurnal and annual variations of the dip and the intensity, these corrections being too small in comparison with the observing errors.

For explanation of the tabular values of  $\theta$ ,  $H$ , and  $F$ , as referred to the adopted epoch 1885.0, see Parts II and III of this paper.

TABLE I.—*Observed magnetic dips and horizontal and total*

## ALABAMA.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Fort Morgan, Mobile Point.	30 13.9	88 01.2	1847	May 19, 20, 29.	----	6.218
Mobile, Batre's garden.	30 41.4	88 01.5	{ 1834 1835 }	May.	61 38	6.115
Mobile.	30 41.6	88 02.6	1857	Feb. 9-25.	60 51.0	6.150
Lower Peach Tree.	31 50.4	87 32.7	1857	Apr. 3; May 2, 4, 5.	62 16.8	5.975
Eufaula.	31 53.7	85 08.4	1860	Apr. 10-14.	63 05.8	5.739
Montgomery, Capitol Square.	32 22.8	86 18.0	1856	Apr. 2, 3, 4, 5, 7, 8	63 05.4	5.859
Tuscaloosa.	33 12	87 42	1835	April.	64 22	----
Indian Mountain.	34 01.8	85 25.6	1875	Aug. 23, 24, 25.	65 09.5	5.472
Decatur.	34 37	86 59	1881	Aug. 26, 27, 29.	65 35.2	5.312
Florence.	34 47	87 43	1881	Sept. 5, 6.	65 52.1	5.297

## ALASKA TERRITORY.

Kyska Harbor, Kyska Island.	51 59.1	* -177 30.0	1873	July 22.	65 01.3	----
Chichagoff Harbor, Attu Island.	52 56.0	+173 12.4	1873	June 26.	65 10.6	----
Unalashka, Cove Point, Chernoffsky Bay.	53 24.0	167 29.9	1880	Oct. 2.	67 13.8	4.544
Unalashka Island, Captain's Harbor.	53 55	-166 30	1778	Oct. 12.	69 23.5	----
Unalashka.	53 52.4	-166 31.9	1817	June.	68 45	----
Unalashka, Captain's Harbor.	53 54	-166 30	1827	Aug. 11.	68 25.6	----
Do.	53 54	-166 30	1829	----	68 26	----
Unalashka, Iliuliuk.	53 52	-166 30	1849	----	68 22	----
Unalashka, Iliuliuk Harbor.	53 52.9	166 31.7	1880	July, Oct.	67 35.8	4.456
Do.	53 52.9	-166 31.7	1883	Sept. 19, 20, 21.	----	4.386
Howcan Mission, Kaigani Straits.	54 49.5	-132 50	1881	Sept. 1, 2.	74 21.5	3.805
Northwest Harbor, Little Koniushi, Shumagin Islands.	55 03.3	-159 23.5	1880	July 16.	69 30.3	4.198
Tamgas Harbor, Gravina Islands.	55 04	-131 28	1883	July 27, 28; Aug. 8.	74 28.2	3.478
Belkoffsky Settlement, Dolgoi Island.	55 05.2	162 00.2	1880	July 23.	69 16.2	4.193
Humboldt Harbor, Popoff Island, Shumagins.	55 19.3	-160 31.0	1880	July 19.	69 28.8	4.208
Ward's Cove, Tongass Narrows.	55 22.7	-131 43.6	1882	Oct. 4.	74 36.2	3.375
Kasaan Bay, Prince of Wales Archipelago.	55 29.5	-132 19.0	1880	May 9.	73 58	----
Shakan, Prince of Wales Islands.	56 09.4	-133 38.5	1881	Aug 15, 16.	74 49.7	3.395
Fort Wrangell, Etolin Harbor.	56 28.2	-132 22.5	1880	May 10.	75 19.2	----
Do.	56 28.2	-132 22.5	1881	Aug. 17-21.	75 32.8	3.265
Hot Springs Bay, Sitka Sound.	56 51.7	-135 20.3	1880	June 9.	75 01.9	3.345
Sitka, a few leagues off shore.	56 54	-135 25	1786	Aug. 6, 7.	73 30 (?)	----
Portage Bay, Prince Frederick Sound.	57 00.2	-133 20.0	1882	Oct. 31, Nov. 1.	75 08.3	3.290

\* West longitudes have negative signs; east longitudes have positive signs.

*magnetic intensities in the United States and adjacent regions.*

## ALABAMA.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°	----	----	R. H. Fauntleroy and J. S. Ruth.	C. & G. S. Rpt., 1881, App. 9.
----	61.1	6.15	12.73	J. N. Nicollet.	C. S. Rpt., 1864, App. 19. Obs'd mean $\theta=63^{\circ} 28'$ ; prob. index cor'n = $-1^{\circ} 50'$ . H mean of obs'ns in May, 1834, and May, 1835, epoch 1834.9.
12.625				E. Goodfellow.	C. & G. S. Rpt., 1881, App. 9.
12.846	62.1	5.98	12.78	G. W. Dean.	Do.
12.684	62.9	5.74	12.60	Do.	Do.
12.946	62.9	5.86	12.87	Do.	Do.
----	64.2	----	----	J. N. Nicollet.	C. S. Rpt., 1864. Dip corrected by $-1^{\circ} 50'$ for probable index cor'n.
13.025	65.01	5.47	12.95	F. P. Webber.	C. & G. S. Rpt., 1881, App. 9.
12.852	65.53	5.312	12.83	J. B. Baylor.	Do.
12.956	65.81	5.297	12.93	Do.	Do.

## ALASKA TERRITORY.

----	64.7	----	----	W. H. Dall.	C. & G. S. Rpt., 1881, App. 9.
----	64.9	----	----	Do.	Do.
11.74	67.1	4.54	11.67	W. H. Dall and M. Baker.	Do.
----	67.5	4.41	11.52	J. Cook.	Encyc. Met. London, 1848. Art. Magnetism.
12.15				O. v. Kotzebue.	F. P. Lütke. Voyage, &c., party nautique.
12.47	67.5	4.41	11.52	F. P. Lütke.	F. P. Lütke. Voyage, &c., party nautique. Rpt. Brit. Asso., vol. VI, 1838.
12.69				Do.	Phil. Trans. R. S., 1872. Sir E. Sabine.
11.69	74.3	3.80	14.04	Tebenkoff.	Tebenkoff's Atlas.
14.11				W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
11.99	69.4	4.18	11.88	R. A. Marr.	MS. in C. & G. S. Office.
12.990	74.4	3.47	12.90	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
11.84	69.2	4.18	11.77	W. H. Dall and M. Baker.	Do.
12.00	69.4	4.19	11.91	Do.	Do.
12.710	74.5	3.37	12.61	H. E. Nichols.	MS. in C. & G. S. Office.
12.97	74.7	3.39	12.85	W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
13.08	75.4	3.26	12.93	H. E. Nichols.	Do.
12.95	74.9	3.34	12.82	W. H. Dall & M. Baker.	Do.
12.828	75.1	3.29	12.79	J. F. G. de La Perouse.	Voyage, &c. Paris, 1797, vol. 3. $\theta$ apparently too small.
				H. E. Nichols.	MS. in C. & G. S. Office.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

ALASKA TERRITORY—Continued.

Name of station.	Latitude φ.	* Longitude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Sitka, near.	57 02.8	—135 06.6	1818	July.	76 33	----
Sitka.	57 03	—135 20	1827	----	75 55	----
Do.	57 03	—135 20	1829.9	----	75 50.6	----
Do.	57 03	—135 22	1837	----	75 51.5	----
Do.	57 03	—135 22	1839	----	75 49.1	3.207
Sitka, Japonski Island Observatory.	57 03	—135 20	1842	----	75 51	----
Do.	57 03	—135 20	1845	Jan. to Dec.	75 54.6	----
Sitka.	57 03	—135 20	1851	----	76 20	----
Sitka, Japonski Island, near old Russian Magnetic Observatory.	57 02.9	—135 20.3	1880	May 17, 18.	75 11.7	3.310
Do.	57 02.9	—135 20.3	1881	Sept. 12–16.	75 16.6	3.293
Saint Paul Island, Pribiloff Islands.	57 07.3	—170 19.0	1880	Aug. 6.	68 36.6	4.356
Kadiak, near Cape Greville.	57 20	—152 51	1839	July.	72 42.9	3.635
Povorotny Station, Peril Strait.	57 28.4	—135 27.5	1880	May 20.	75 03.4	----
Marble Bluff, Chatham Strait.	57 45	—134 43.5	1880	May 22.	75 57.3	----
Saint Paul, Kadiak Island.	57 48.0	—152 21.3	1880	July 12.	72 34.6	3.721
New Point Marsden, Admiralty Island.	58 05	—134 49	1880	May 23.	76 02.1	3.124
Cross Sound, Granite Cove, Port Althorp.	58 12	—136 24	1794	July.	78 58.5	----
Port Althorp, Cross Sound.	58 11.5	136 23.5	1880	June 19.	75 22.3	3.279
Point Whidbey, Lynn Canal.	58 36.5	—135 15	1880	May 24.	76 27.3	----
Lituya Bay (Port Français).	58 39	—137 30	1786	----	73 52 (?)	----
Seduction Island, Lynn Canal.	58 59.5	—135 22	1880	May 29.	76 44.3	----
Pyramid Island Harbor, Lynn Canal.	59 10.6	—135 28.5	1880	May 25, 26.	75 34.7	3.277
Kohklux.	59 23.7	—135 53.5	1869	July 31, Aug. 2, 3.	75 44	3.297
Port Mulgrave.	59 33.7	—139 46.3	1791	July 1.	76 46.8	----
Do.	59 33.7	—139 45.9	1880	June 24.	76 17.9	3.067
Coal Point, Cook's Inlet.	59 36.1	—151 23.6	1880	June 30.	73 59.6	3.464
Chalmer's Haven.	60 16	—147 25	1794	----	77 08.5	----
Port Etches.	60 21	—146 41	1837	----	76 02.9	3.150
Saint Michael's, Norton Sound.	63 29.8	—162 05.7	1879	----	75 06	----
Norton Bay.	64 31	—162 47	1778	----	76 25	----
Port Clarence and Grantley Bay.	65 17	—166 19	1850	----	75 48	----
Do.	65 17	—166 19	1854	----	{ 77 26 (?) 76 30 }	----
Port Clarence.	65 17	—166 30	1879	July.	76 05	3.028
Do.	65 16.1	—166 50.6	1880	Sept. 6, 8.	76 04.0	3.022

\* West longitudes have negative signs; east longitudes have positive signs.

*intensities in the United States and adjacent regions.—Continued.*

## ALASKA TERRITORY—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
-----	°			V. M. Golovnin.	Voyage around the world. St. Petersburg, 1822, vol. II.
13. 14				F. P. Lütke.	Rpt. Brit. Asso., vol. VI, London, 1838, & Phil. Trans. R. S., 1872. Sabine's value, $F = 12.98$ .
13. 07				A. Erman.	Rpt. Brit. Asso., vol. VI, London, 1838, & Phil. Trans. R. S., 1872. Sabine's value, $F = 12.90$ .
-----				E. Belcher.	Phil. Trans. R. S., 1843, pt. 2. & 1872. Sabine's value for 1837 & 1839, $F = 12.77$ .
13. 10	75. 15	3. 30	12. 88	Do.	Do.
-----				Observatory.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883, p. xxi.
-----				Do.	M. Baker from Annuaire Met. & Mag., St. Petersburg.
-----				Collinson.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883, p. xxi.
12. 95				W. H. Dall & M. Baker.	C. & G. S. Rpt., 1881, App. 9.
12. 96				H. E. Nichols.	Do.
11. 94	68. 5	4. 35	11. 87	W. H. Dall & M. Baker.	Do.
12. 11	-----	-----	-----	E. Belcher.	Phil. Trans. R. S., 1843 & 1872.
-----	74. 9	-----	-----	W. H. Dall & M. Baker.	C. & G. S. Rpt., 1881, App. 9.
-----	75. 8	-----	-----	Do.	Do.
12. 43	72. 5	3. 72	12. 37	Do.	Do.
12. 94	75. 9	3. 12	12. 81	Do.	Do.
-----	75. 2	3. 28	12. 84	G. Vancouver.	Encyc. Met., London, 1848, Art. Magnetism, & Vancouver's Voyage, Vol. III.
12. 98				W. H. Dall & M. Baker.	C. & G. S. Rpt., 1881, App. 9.
-----	76. 3	-----	-----	Do.	Do.
-----	-----	-----	-----	J. F. G. de La Prouse.	Encyc. Met., London, 1848, Art. Magnetism.
-----	76. 6	-----	-----	W. H. Dall & M. Baker.	C. & G. S. Rpt., 1881, App. 9.
13. 15	75. 5	3. 28	13. 10	Do.	Do.
13. 38	75. 3	3. 29	12. 97	G. Davidson.	Do.
-----	76. 2	3. 06	12. 83	Don A. Malaspina.	Bode's Astr. Jahrb., Berlin, 1828.
12. 95				W. H. Dall & M. Baker.	C. & G. S. Rpt., 1881, App. 9.
12. 56	73. 9	3. 46	12. 48	Do.	Do.
-----	-----	-----	-----	G. Vancouver.	Encyc. Met., London, 1848, Art. Magnetism.
12. 94	-----	-----	-----	E. Belcher.	Phil. Trans. R. S., 1843 & 1872.
-----	75. 0	-----	-----	U. S. Revenue Marine.	Pacific Coast Pilot, U. S. C. & G. S., 1883.
-----	-----	-----	-----	J. Cook.	Encyc. Met., London, 1848, Art. Magnetism, & Vancouver's Voyage, Vol. III.
-----	76. 0	3. 025	12. 50	Collinson.	Phil. Trans. R. S., 1872.
-----				Do.	Do.
-----				R. Maguire.	
12. 59				A. Wykander.	Nordenskiöld in the Vega.
12. 55				W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

ALASKA TERRITORY—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	$^{\circ}$ /	$^{\circ}$ /			$^{\circ}$ /	
Kotzebue Sound, Chamisso Island.	66 13	—161 49	1827	----	77 39	----
Chamisso Harbor, Kotzebue Sound.	66 13.3	—161 48.7	1880	Aug. 31.	77 17.4	2.791
Fort Yukon.	66 33.8	—145 17.8	1869	Aug. 14, 16, 26.	79 49.5	2.478 (?)
Near Cape Lisburne.	68 52.9	—166 05.5	1880	Aug. 21.	78 53.0	2.460
On ice, near Nuwnak.	70 09	—143 50	1851	----	82 58	----
Sandy Beach, between Port Lay and Icy Cape.	70 13.2	—162 15.2	1880	Aug. 25.	80 07.8	2.195
Foggy Island.	70 16	—147 38	1825	----	82 26	----
Near Point Belcher.	70 47	—159 40	1880	Aug. 27.	80 52.6	2.025
Ooglaamie, Point Barrow.	71 17.7	—156 39.7	1881	Dec.	81 24.6	1.932
Do.	71 17.7	—156 39.7	1882	Jan. to Dec.	81 23.5	1.935
Do.	71 17.7	—156 39.7	1883	Jan. to July and Aug.	81 23.1	1.937
Plover Point, Point Barrow.	71 21.4	—156 16.1	1854	----	81 36	----
Point Barrow, near extreme point.	71 22.5	—156 20	1881	Summer.	81 18	----
On ice, north and east of Point Barrow.	71 26	—147 26	1851	----	83 05	----
On ice.	71 27	—155 14	1851	----	82 29	----

## ARIZONA TERRITORY.

Santa Cruz River.	31 18	110 31	1855	May 14.	57 28	6.169
San Bernardino.	31 20	109 14	1855	Apr. 28.	57 19	6.252
Los Nogales.	31 21	110 51	1855	June 16.	57 13	6.262
Station 45.	32 41	114 05	1851	----	58 25	----
Gila Junction.	32 43	114 33	1851	----	58 30	----
Station 44.	32 44	113 50	1851	----	58 30	----
Station 43.	32 49	113 33	1851	----	58 43	----
Station 1.	32 50	109 34	1851	----	59 19	----
Station 2.	32 50	109 37	1851	----	59 12	----
Station 3.	32 53	109 44	1851	----	59 12	----
Station 4.	32 57	109 49	1851	----	59 20	----
Station 42.	32 58	113 11	1851	----	59 17	----
Station 20.	32 59	110 40	1851	----	59 11	----
Station 39.	32 59	112 43	1851	----	58 49	----
Station 38.	33 00	112 39	1851	----	58 53	----
Station 28.	33 01	111 23	1851	----	59 16	----
Station 40.	33 02	112 55	1851	----	59 16	----
Station 21.	33 03	110 46	1851	----	58 59	----
Station 27.	33 03	111 16	1851	----	59 20	----
Station 5.	33 04	109 55	1851	----	59 27	----
Station 26.	33 04	111 11	1851	----	59 25	----
Station 29.	33 04	111 34	1851	----	59 06	----

ALASKA TERRITORY—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.		
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$				
-----	o						
12. 68	} 77. 2	2. 79	12. 59 {	Beechey.	Beechey's Voyage to the Pacific, London, 1831.		
14. 02(?)						W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
	79. 5	----	----	C. W. Raymond.	Senate Ex. Doc. No. 12, Wash., 1871. H doubtful; first set of deflections alone used.		
12. 76	78. 8	2. 46	12. 66	W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.		
----	----	----	----	Collinson.	Phil. Trans. R. S., 1872.		
12. 81	80. 0	2. 20	12. 67	W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.		
----	----	----	----	J. Franklin.	Phil. Trans. R. S., 1872.		
12. 84	80. 8	2. 03	12. 70	W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.		
12. 935	} 81. 34	1. 950	12. 95 {	P. H. Ray.	C. & G. S. Rpt., 1883, App. 13.		
12. 929						Do.	Do.
12. 927						Do.	Do.
----	----	----	----	R. Maguire.	Phil. Trans. R. S., 1872.		
----	81. 23	----	----	U. S. Revenue Marine.	Pacific Coast Pilot, Alaska, U. S. C. & G. S., 1883.		
----	----	----	----	Collinson.	Phil. Trans. R. S., 1872.		
----	----	----	----	Do.	Do.		

## ARIZONA TERRITORY.

[illegible]

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
ARIZONA TERRITORY.—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Station 19.	33 05	110 35	1851	----	59 05	----
Station 22.	33 05	110 50	1851	----	59 13	----
Station 6.	33 06	110 00	1851	----	59 38	----
Station 24.	33 06	111 02	1851	----	59 20	----
Station 23.	33 07	110 55	1851	----	59 23	----
Station 30.	33 08	111 44	1851	----	59 06	----
Station 12.	33 09	110 26	1851	----	59 37	----
Station 13.	33 09	110 28	1851	----	58 58	----
Station 15.	33 09	110 31	1851	----	59 28	----
Station 32.	33 09	111 57	1851	----	59 22	----
Station 7.	33 10	110 03	1851	----	59 42	----
Station 31.	33 10	111 54	1851	----	59 28	----
Station 8.	33 12	110 10	1851	----	59 37	----
Station 10.	33 12	110 19	1851	----	59 34	----
Station 17.	33 12	110 42	1851	----	59 23	----
Station 9.	33 13	110 19	1851	----	59 45	----
Williams River.	34 13	113 33	1854	Feb. 15.	60 08	----
Camp 123.	34 14	113 39	1854	Feb. 16.	60 10	----
Williams River.	34 17	113 26	1854	Feb. 13.	60 14	----
Camp 126.	34 17	113 56	1854	Feb. 20.	60 11	----
On Colorado River.	34 23	114 06	1854	Feb. 21.	60 34	----
Camp 129.	34 27	114 11	1854	Feb. 22.	60 35	----
Williams River.	34 32	113 28	1854	Feb. 9.	60 44	----
Do.	34 36	113 28	1854	Feb. 8.	60 36	----
Camp 130.	34 36	114 16	1854	Feb. 23.	60 30	----
Camp 132.	34 46	114 23	1854	Feb. 25	60 48	----
Camp 135.	34 52	114 32	1854	Mar. 1.	60 57	----
Colorado Chiquito or Flax River.	34 53	110 04	1853	Dec. 5.	62 15	----
Pueblo Creek.	34 56	112 46	1854	Jan. 21.	61 13	----
Near Rio Puerco of the West.	34 58	109 52	1853	Dec. 3.	61 46	----
Williams River.	34 59	112 57	1854	Jan. 23.	61 06	----
On Colorado Chiquito.	35 00	110 25	1853	Dec. 7.	61 54	----
Do.	35 01	110 30	1853	Dec. 8.	61 41	----
Big Horse Spring.	35 01	113 36	1854	Feb. 4.	61 02	----
Near Lithodendron Creek.	35 02	109 41	1853	Dec. 2.	61 57	----
Jacob's Well.	35 04	109 14	1853	Nov. 29.	61 59	----
On Colorado Chiquito.	35 05	110 33	1853	Dec. 15.	61 44	----
Navajo Springs.	35 06	109 20	1853	Nov. 30.	61 58	----
Carriso Creek.	35 06	109 32	1853	Dec. 1.	62 05	----
Williams River.	35 07	113 13	1854	Jan. 28.	61 17	----
White Cliff Creek.	35 08	113 31	1854	Feb. 1.	60 48	----
On Colorado Chiquito.	35 12	110 37	1853	Dec. 16.	61 45	----

*intensities in the United States and adjacent regions.—Continued.*

## ARIZONA TERRITORY—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°	----	----	W. H. Emory and T. W. Chandler.	U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vols. V & VI, 1856.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
12. 11	----	5. 90	----	J. C. Ives and A. W. Whipple.	C. S. Rpt., 1856, p. 222.
12. 07	----	5. 88	----	Do.	Do.
12. 13	----	5. 89	----	Do.	Do.
12. 06	----	5. 87	----	Do.	Do.
12. 09	----	5. 81	----	Do.	Do.
12. 10	----	5. 81	----	Do.	Do.
12. 10	----	5. 79	----	Do.	Do.
12. 06	----	5. 79	----	Do.	Do.
12. 10	----	5. 83	----	Do.	Do.
12. 11	----	5. 78	----	Do.	Do.
12. 16	----	5. 77	----	Do.	Do.
12. 42	----	5. 65	----	Do.	Do.
12. 28	----	5. 78	----	Do.	Do.
12. 41	----	5. 74	----	Do.	Do.
12. 25	----	5. 79	----	Do.	Do.
12. 39	----	5. 71	----	Do.	Do.
12. 37	----	5. 74	----	Do.	Do.
12. 13	----	5. 74	----	Do.	Do.
12. 40	----	5. 70	----	Do.	Do.
12. 46	----	5. 72	----	Do.	Do.
12. 36	----	5. 72	----	Do.	Do.
12. 47	----	5. 73	----	Do.	Do.
12. 45	----	5. 70	----	Do.	Do.
12. 03	----	5. 65	----	Do.	Do.
12. 25	----	5. 85	----	Do.	Do.
12. 41	----	5. 74	----	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

ARIZONA TERRITORY—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Head of White Cliff Creek.	35 12	113 21	1854	Jan. 30.	61 14	----
Saroux Spring.	35 17	111 39	1853	Dec. 29.	61 33	----
On Colorado Chiquito.	35 18	110 53	1853	Dec. 17.	61 55	----
Do.	35 21	110 56	1853	Dec. 18.	62 03	----
Cedar Creek.	35 21	112 20	1854	Jan. 9.	62 06	----

## ARKANSAS.

[No magnetic dip or intensity stations in the State.]

## CALIFORNIA.

San Diego.	32 42	117 14	1793	Nov. and Dec.	59 13	----
San Diego, tongue on eastern side.	32 41	117 13	1839	----	57 06.1	6.142
San Diego.	32 42	117 10	1849	----	57 33	----
San Diego, La Playa.	32 42.2	117 14.5	1853	Sept. and Oct.	57 38.6	6.271
San Diego Bay.	32 42	117 13	1866	June 15.	57 54	6.261
San Diego, La Playa.	32 42.2	117 14.6	1872	Nov. 22, 23.	57 56.8	6.159
Do.	32 42.2	117 14.5	1881	Apr. 5, 6.	57 51.2	6.104
New River.	32 42	115 25	1849	----	58 19	----
Santa Maria.	33 02	116 51	1849	----	58 42	----
Santa Isabella.	33 08	116 41	1849	----	58 48	----
San Pedro, on a small island 3 miles north of San Pedro.	33 43	118 15	1839	----	58 21.4	5.913
San Pedro.	33 45.4	118 17.0	1853	Nov. and Dec.	59 32.6	6.144
Do.	33 44.2	118 16.7	1881	Apr. 10, 11.	58 48.5	5.991
Dominguez Hill.	33 51.8	118 14.2	1870	Mar. 17, 18.	58 49.2	6.056
Santa Monica.	34 00.5	118 29.7	1883	Apr. 10.	59 02.8	5.973
Los Angeles, Coast and Geodetic Survey Observatory.	34 03.0	118 15.4	1882	Sept., Oct., Nov., Dec.	59 30.4	5.9126
Do.	34 03.0	118 15.4	1883	Monthly.	59 30.7	5.9191
Do.	34 03.0	118 15.4	1884	Monthly.	59 29.4	5.9151
Do.	34 03.0	118 15.4	1885	Jan'y to July.	59 29.8	5.9111
San Buenaventura.	34 15.8	119 15.9	1870	Jan. 13-19.	59 11.5	6.018
Santa Barbara.	34 24	119 42	1831	May.	60 48	5.861
Santa Barbara, at landing place.	34 24	119 42	1839	----	58 54.1	5.925
Santa Barbara, N. NW. of Geodetic station on outermost spur of hill.	34 24.2	119 42.8	1869	Nov. 20-25.	59 16.0	5.967
Santa Barbara, west of long wharf near Burton House.	34 24.6	119 41.5	1881	Apr. 13, 14.	59 19.2	5.871

*intensities in the United States and adjacent regions.—Continued.*

## ARIZONA TERRITORY—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
12. 34	° ----	5. 81	----	J. C. Ives and A. W. Whipple.	C. S. Rpt. 1856, p. 222.
12. 34	----	5. 75	----	Do.	Do.
12. 40	----	5. 71	----	Do.	Do.
12. 48	----	5. 72	----	Do.	Do.
12. 46	----	5. 70	----	Do.	Do.

## ARKANSAS.

[No magnetic dip or intensity stations in the State.]

## CALIFORNIA.

----				G. Vancouver.	Hansteen's Erdmagnetismus, Christiania, 1819.
11. 32				E. Belcher.	Phil. Trans. R. S., 1841 and 1843, and C. S. Rpt. 1861, App. 22.
----				W. H. Emory.	U. S. and Mex. Bound. Sur.; Am. Acad. Sci., Vol. VI, 1856.
11. 72	57. 88	6. 087	11. 45	W. P. Trowbridge.	C. & G. S. Rpt., 1881, App. 9.
11. 782				W. Harkness.	Smithsonian Cont's to Know., No. 239, Wash., 1873. Prof. W. Harkness, U. S. N.
11. 60				S. R. Throckmorton.	C. & G. S. Rpt., 1881, App. 9.
11. 47				H. E. Nichols.	Do.
----	58. 3	----	----	W. H. Emory.	U. S. & Mex. Bound. Sur.; Am. Acad. Sci., Vol. VI, 1856.
----	58. 7	----	----	Do.	Do.
----	58. 8	----	----	Do.	Do.
11. 28				E. Belcher.	Phil. Trans. R. S., 1841; C. S. Rpt., 1861, App. 22.
12. 12	58. 8	5. 968	11. 52	W. P. Trowbridge.	C. & G. S. Rpt., 1881, App. 9.
11. 57				H. E. Nichols.	Do.
11. 70	58. 8	5. 970	11. 52	G. Davidson and S. R. Throckmorton.	Do.
11. 613	59. 1	5. 965	11. 62	M. Baker.	M. S. in C. & G. S. Office.
11. 652				M. Baker.	Do.
11. 666	59. 50	5. 911	11. 65	Do.	Do.
11. 651				M. Baker and C. Terry.	Do.
11. 646				C. Terry.	Do.
11. 75	59. 2	5. 932	11. 58	G. Davidson and S. R. Throckmorton.	C. & G. S. Rpt., 1881, App. 9.
12. 02				D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1875; Sir E. Sabine's Cont., XIV, and C. S. Rpt., 1861, App. 22.
11. 48	59. 29	5. 860	11. 47	E. Belcher.	Phil. Trans. R. S., 1841 and 1843; C. S. Rpt., 1861, App. 22.
11. 68				G. Davidson and S. R. Throckmorton.	C. & G. S. Rpt., 1881, App. 9.
11. 51				H. E. Nichols.	Do.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

CALIFORNIA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	$^{\circ}$ /	$^{\circ}$ /			$^{\circ}$ /	
Point Conception, El Coxo.	34 27.0	120 26.7	1872	Dec. 9, 10, 11.	58 51.0	5.905
Santa Inez.	34 36	120 11	1831	May.	60 53	5.818
La Purissima.	34 40	120 27	1831	May.	60 53	5.788
Soda Lake.	35 03	115 59	1854	Mar. 8.	61 07	----
Pai-ute Creek.	35 06	114 54	1854	Mar. 3.	61 10	----
Sand Camp.	35 06	115 46	1854	Mar. 7.	60 49	----
San Luis Obispo.	35 11	120 44	1831	May.	61 17	5.754
Do.	35 10.6	120 44.5	1854	Jan. and Feb.	59 42.2	6.002
Do.	35 10.6	120 44.5	1881	Apr. 16, 17.	60 30.0	5.831
Near Marl Spring.	35 11	115 33	1854	Mar. 6.	60 56	----
San Miguel.	35 45	121 00	1831	Apr.	61 40	5.686
San Antonio.	36 01	121 18	1831	Apr.	61 46	5.674
La Soledad.	36 24	121 24	1831	Apr.	62 04	5.661
Mount Toro.	36 31.5	121 36.5	1885	Jan. 27 to Feb. 2.	----	5.663
Monterey.	36 36	121 51	1791	Sept. 23.	60 56.2	----
Do.	36 36	121 51	1792	Dec.	63 00.5	----
Do.	36 36	121 51	1794	Nov.	63 00	----
Monterey, at the presidio.	36 36	121 53	1818	Sept.	64 15	----
Monterey, near landing place.	36 35	121 55	1831	Jan.	62 07.5	5.629
Do.	36 36	121 53	1839	----	61 03.6	5.666
Monterey.	36 36	121 53	1843	Sept.	61 58.9	----
Monterey, at the barracks of redoubt.	36 36.2	121 53.8	1854	May 19-25.	60 59.5	5.802
Near Monterey, Point Pinos.	36 37.8	121 55.6	1873	Sept. 1, 2.	61 12.5	5.696
Monterey, at the barracks, officers' quarters.	36 36.2	121 53.8	1881	Apr. 19, 20.	61 12.7	5.663
Mt. Bache, or Loma Prieta.	37 06.6	121 50.6	1884	Mar. 15, 16, 17.	----	5.591
Sierra Morena.	37 24.5	122 18.5	1884	Jan. 15, 16, 17.	----	5.541
San José.	37 32	122 00	1831	July.	62 52	5.550
San Francisco Bay.	37 48.5	122 22	1815	Nov. 1.	62 46	----
San Francisco.	37 48	122 24	1829	----	----	----
Do.	37 48	122 24	1831	Feb.	62 58.0?	5.495
Do.	47 48	122 24	1837	----	61 53.8	----
San Francisco, Yerba Buena Island.	37 48	122 24	1839	----	62 05.8	5.524
San Francisco, presidio.	37 47.5	122 27.2	1852	Feb. 11, 12.	62 21.2	----
San Francisco, Dupont street, near Catholic church, and near Stockton and California sts.	37 47.8	122 24.0	1858	June 5, 6, 7, 10, 13	62 47	5.591 5.561
San Francisco.	37 49	122 21	1866	June 26.	62 22	5.643

*intensities in the United States and adjacent regions —Continued.*

CALIFORNIA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
11. 41	58. 9	5. 836	11. 30	S. R. Throckmorton.	C. & G. S. Rpt., 1881, App. 9.
11. 96	----	5. 818	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI. 1838, and Phil. Trans. R. S., 1841 and 1875.
11. 89	----	5. 788	----	Do.	Do.
12. 15	----	5. 763	----	J. C. Ives and A. W. Whipple.	C. S. Rpt., 1856, p. 222.
12. 16	----	5. 758	----	Do.	Do.
12. 14	----	5. 814	----	Do.	Do.
11. 96	60. 50	5. 821	11. 82	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 and 1875; C. S. Rpt., 1861, App. 22.
11. 90				W. P. Trowbridge.	C. & G. S. Rpt., 1881, App. 9.
11. 84				H. E. Nichols.	Do.
12. 10				J. C. Ives and A. W. Whipple.	C. S. Rpt., 1856, p. 222.
11. 96	----	5. 686	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 and 1875.
11. 99	----	5. 674	----	Do.	Do.
12. 04	----	5. 661	----	Do.	Do.
----	----	5. 663	----	G. Davidson and F. Morse.	MS. in C. & G. S. Office.
----	61. 21	5. 647	11. 73	Don A. Malaspina.	Bode's Astr. Jahrb., Berlin, 1828.
----				G. Vancouver.	Hansteen's Erdmagnetismus, Christiania, 1819.
----				Do.	Do.
----				V. M. Golovnin.	Voyage round the World, St. Petersburg, 1822, Vol. 2.
12. 07				D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; C. S. Rpt., 1861, App. 22.
11. 71				E. Belcher.	Phil. Trans. R. S., 1843.
----				T. Perry.	Sill. J., Vol. XLVII.
11. 96				W. P. Trowbridge.	C. & G. S. Rpt., 1881, App. 9.
11. 83				S. R. Throckmorton.	Do.
11. 76				H. E. Nichols.	Do.
----	----	5. 588	----	G. Davidson and R. A. Marr.	MS. in C. & G. S. Office.
----	----	5. 536	----	Do.	Do.
12. 17	----	5. 550	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 and 1875.
----	62. 33	5. 495	11. 83	Kotzebue.	Voyage of Discovery, 1815-1818.
12. 00				Erman.	Phil. Trans. R. S., 1846.
12. 09				D. Douglas.	Rpt. Brit. Asso., Vol. VI., 1838; C. S. Rpt., 1861, App. 22. Gauss gives 62° 38' in his comparison of theory and observation.
----				E. Belcher.	Phil. Trans. R. S., 1841.
11. 81				Do.	Phil. Trans. R. S., 1841 and 1843; C. S. Rpt., 1861, App. 22.
----				G. Davidson and F. A. Roe	C. & G. S. Rpt., 1881, App. 9.
12. 19				K. Friesach.	Acad. Sc., Vienna, Vol. 38, 1860.
12. 10				W. Harkness.	Smithsonian Cont's to Know., No. 239, Wash., 1873, Cruise of the Monadnock.
12. 167					

H. Ex. 18—19

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

CALIFORNIA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
San Francisco, Presidio.	37 47.5	122 27.2	1873	Nov. 13-20.	62 05.1	5.543
Do.	37 47.5	122 27.2	1880	Apr. and Nov.	62 18.8	5.526
Do.	37 47.5	122 27.2	1880	Sept. 24-26.	62 19.0	5.501
Do.	37 47.5	122 27.2	1881	Mar. 30; Apr. 1.	62 17.6	5.537
Do.	37 47.5	122 27.2	1881	Apr. to Nov.	62 30.0	5.488
San Francisco, Lafayette Park.	37 47.4	122 25.6	1881	Feb. and June.	62 17.8	5.537
San Francisco, Presidio.	37 47.5	122 27.2	1881	June, July, Dec.	62 25.2	5.530
Do.	37 47.5	122 27.2	1883	June 2, 3, 4, 5.	----	5.481
Do.	37 47.5	122 27.2	1884	Sept. 5-24.	62 20.2	5.485
Mount Diablo.	37 52.8	121 54.8	1884	Nov. 29, 30; Dec. 2, 3, 5.	----	5.542
San Francisco, Solano.	38 17	122 24	1831	July.	63 24	5.467
Port Bodega.	38 18	123 02	1839	----	62 53.4	5.440
Bodega Head, Fort Rumantsoff.	38 18.7	122 43.2	1818	Sept.	65 30	----
Bodega, near geodetic station.	38 18.2	123 00.1	1860	Aug. 15-17.	----	5.558
Vaca.	38 22.4	122 05.0	1880	Nov. 23-29.	----	5.476
Sacramento.	38 35	121 27	1852	----	64 03	----
Sacramento, grounds of the Capitol.	38 36.1	121 28.0	1881	Apr. 5, 6, 7.	63 40.7	5.368
Monticello.	38 39.7	122 11.4	1880	Oct 6-16.	63 14.2	5.419
Blue Cañon.	39 15.3	120 47.0	1881	Apr. 9-10.	64 22.3	5.260

## COLORADO.

La Junta, near eclipse station.	37 58.9	103 32.6	1878	July 25.	66 02.3	5.2761
Pueblo.	38 12	104 37	1872	Oct. 15, 16.	66 38.3	5.124
North Pueblo, south of Court-House.	38 18	104 36.8	1878	Aug. 19-23.	66 31.3	5.183
Colorado Springs.	38 50.0	104 49.1	1873	Aug. 30; Sept. 3.	66 51.4	5.041
Manitou, near the Navajo Soda Spring.	38 51.9	104 54.6	1878	Aug. 4.	66 59.2	5.0649
Denver, on Pierce's Block.	39 45	105 00	1872	Oct. 13, 14, 19.	67 34.4	4.945
Denver, at astronomical station.	39 45.4	104 59.5	1873	Aug. 13, 14, 15.	67 27.2	4.985
Denver, near Seventeenth street and Broadway.	39 45.3	104 59.5	1878	Sept. 3-6.	67 30.7	4.968
Denver, Mrs. Craig's garden.	39 45.3	104 59.6	1878	Aug. 8.	67 32.8	4.9847

## CONNECTICUT.

Stamford.	41 03.5	73 32.3	1844	Sept. 12, 13.	73 02.3	3.885
Norwalk.	41 07.1	73 24.6	1844	Sept. 14.	73 09.8	----
Bridgeport.	41 10	73 11	1845	Sept. 17.	73 21.3	3.738

*intensities in the United States and adjacent regions.—Continued.*

## CALIFORNIA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
11. 84	62. 33	5. 495	11. 83	G. Davidson, S. R. Throckmorton, and W. Eimbeck.	C. & G. S. Rpt., 1881, App. 9.
11. 89				W. H. Dall and M. Baker.	Do.
11. 84				H. E. Nichols.	Do.
11. 91				W. Eimbeck and R. A. Marr.	Do.
11. 89				H. E. Nichols.	Do.
11. 91				J. S. Lawson.	Do.
11. 94				Do.	Do.
----				R. A. Marr.	MS. in C. & G. S. Office.
11. 82				G. Davidson and R. A. Marr.	Do.
----				G. Davidson and R. A. Marr.	Do.
12. 22	----	5. 467	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 & 1875.
11. 94	----	5. 435	----	E. Belcher.	Phil. Trans. R. S., 1841 & 1843.
----	}	5. 443	{	V. M. Golovnin.	Voyage 'round the World, St. Petersburg, 1822, Vol. 2.
----				G. Davidson.	C. & G. S. Rpt., 1881, App. 9.
----	----	5. 454	----	E. F. Dickins.	Do.
----	}	5. 350	{	W. H. Emory.	U. S. & Mex. Bound. Sur.; Am. Acad. Sc., Vol. VI, 1856.
12. 11				W. Eimbeck and R. A. Marr.	C. & G. S. Rpt., 1881, App. 9.
12. 03	63. 25	5. 397	11. 99	G. Davidson and J. J. Gilbert.	Do.
12. 16	64. 35	5. 242	12. 11	W. Eimbeck and R. A. Marr.	Do.

## COLORADO.

12. 991	66. 0	5. 28	12. 98	T. E. Thorpe.	Proc. R. S., No. 200, 1880.
----	}	5. 15	12. 91	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, (Nat. Acad. Ser.)
13. 01				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
12. 83	}	5. 05	12. 87	E. Smith.	Do.
12. 956				T. E. Thorpe.	Proc. R. S., No. 200, 1880.
----	}	4. 97	12. 99	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, (Nat. Acad. Ser.)
13. 00				E. Smith.	C. & G. S. Rpt., 1881, App. 9.
12. 99				J. B. Baylor.	Do.
13. 051				T. E. Thorpe.	Proc. R. S., No. 200, 1880.

## CONNECTICUT.

13. 32	72. 17	3. 944	12. 88	J. Renwick.	C. & G. S. Rpt., 1881, App. 9.
----	72. 29	----	----	Do.	Do.
13. 05	72. 48	3. 805	12. 64	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

CONNECTICUT - Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Double Beach.	41 14.5	72 51	1884	July 22.	72 50.4	----
Light-House point.	41 15	72 54	1884	June 30.	72 46.1	----
Tashua.	41 15.6	73 15.0	1863	Aug. 31; Sept. 17	73 00.8	3.887
Saybrook.	41 16.5	72 20.6	1845	Aug. 19.	74 33.8	3.564
New Haven, burial ground.	41 18	72 56	1839	Sept.	73 26.7	3.832
New Haven.	41 18	72 57	1842	Apr. 21.	73 29.8	3.819
New Haven, Grove Street, near cemetery.	41 18	72 57	1842	Oct. 18.	73 27.4	3.831
New Haven, Yale College and station south- east of it.	41 18.5	72 55.7	1844	Aug. 27-29.	{ 73 21.0 27.5 }	{ 3.818 }
New Haven, Fort Wooster.	41 16.9	72 53.6	1847	Sept. 27-Oct. 2.	74 16.6	3.667
New Haven, at the Pavilion.	41 18.0	72 54.6	1848	Aug. 14-18.	73 31.9	3.776
New Haven, Fort Wooster.	41 16.9	72 53.6	1848	Aug. 21-26.	74 12.6	3.617
New Haven, Oyster Point.	41 17.0	72 55.7	1848	Aug. 30, 31.	73 32.9	3.769
Do	41 16.9	72 55.8	1855	Aug. 17.	73 44.5	3.690
New Haven, Silliman's Garden.	41 18.7	72 55.6	1878	July 17, 18.	73 05.4	3.861
New Haven, Yale College Observatory.	41 18.7	72 55.6	1884	Jan. to Dec.	72 49.6	3.8704
Do.	41 18.7	72 55.6	1885	Apr. 22.	72 47.6	3.860
New London.	41 18.4	72 00.3	1845	Aug. 13.	72 57.9	----
Stonington.	41 19.8	71 54.3	1845	Aug. 8, 9.	73 25.1	3.748
Wooster.	41 21.0	73 29.3	1864	July 20; Aug. 6.	73 24.6	3.818
Centreville.	41 23.0	72 54.2	1884	June, Aug.	72 49.9	----
Sandford.	41 27.7	72 57.0	1862	Sept. 30; Oct. 10.	73 33.3	3.855
Hartford, northwest of State-House.	41 46	72 41	1839	Sept.	73 58.1	----
Hartford, in park.	41 45.9	72 40.5	1859	July 27.	74 07.4	3.716
Hartford, yard of Perkins' house, Prospect street.	41 45.9	72 40.4	1867	Aug. 15, 17.	73 20.5	3.801
Hartford, in park.	41 45.9	72 40.5	1879	July 24, 25.	73 25.7	3.783
Box Hill.	41 47.9	72 27.3	1861	Oct. 21-25.	73 57.9	3.743
Ivy.	41 52.3	73 13.5	1863	June 23; July 17.	73 32.0	3.792
Bald Hill.	41 58.3	72 11.9	1861	Sept. 10-20.	73 47.5	3.715

## DAKOTA TERRITORY.

Yankton.	42 54	97 28	1880	Oct. 9, 11.	72 52.2	4.124
Bismarck	46 46.3	100 38	1880	Sept. 21, 22.	74 55.7	3.617
Jamestown.	46 53.2	98 45	1880	Sept. 15, 16.	75 35.7	3.457
Pembina	48 59	97 14	1880	Sept. 9, 10.	77 27.9	3.033

*intensities in the United States and adjacent regions.—Continued.*

## CONNECTICUT—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	•	H <sub>1885.0</sub>	F <sub>1885.0</sub>		
13. 178	72. 75	3. 897	13. 14	O. T. Sherman.	Rpt. to Board of Managers of Yale Coll. Observatory, 1884-'85.
13. 159				Do.	Do.
13. 30	72. 03	3. 987	12. 92	S. H. Lyman, G. W. Dean, and A. D. Bache.	C. & G. S. Rpt., 1881, App. 9.
13. 39	73. 69	3. 631	12. 93	J. Renwick.	Do.
13. 35				E. Loomis.	Sill. J., 1840; Am. Phil. Soc., Vol. VIII, 1843; C. S. Rpt., 1861, App. 22.
13. 45				J. Locke.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13. 453				J. H. Lefroy.	Diary Mag. Sur., Canada, London, 1883.
13. 33				J. Renwick.	C. & G. S. Rpt., 1881, App. 9.
13. 53	72. 73	3. 865	13. 02	R. H. Fauntleroy.	Do.
13. 32				J. S. Ruth.	Do.
13. 29				Do.	Do.
13. 31				Do.	Do.
13. 18				C. A. Schott.	Do.
13. 274				T. E. Thorpe.	Proc. R. S., No. 200, 1880.
----				O. T. Sherman.	Rpt. to Board of Managers of Yale Coll. Observatory, 1883-'84.
----				Do.	Rpt. to Board of Managers of Yale Coll. Observatory, 1884-'85.
----	72. 09	----	----	J. Renwick.	C. & G. S. Rpt., 1881, App. 9.
13. 13	72. 54	3. 814	12. 71	Do.	Do.
13. 37	72. 43	3. 913	12. 96	R. E. Halter and A. D. Bache.	Do.
13. 129	72. 78	3. 878	13. 10	O. T. Sherman.	Rpt. Board of Managers of Yale Coll. Observatory, 1884-'85.
13. 62	72. 58	3. 960	13. 23	E. Goodfellow and A. D. Bache.	C. & G. S. Rpt., 1881, App. 9.
----	72. 76	3. 840		E. Loomis.	Sill. J., Vol. XXXIX, 1840.
13. 58				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 26			12. 96	Do.	Do.
13. 26				J. B. Baylor.	Do.
13. 55	72. 96	3. 854	13. 15	G. W. Dean, R. E. Halter, and A. D. Bache.	Do.
13. 38	72. 55	3. 892	12. 98	S. H. Lyman, G. W. Dean, and A. D. Bache.	Do.
13. 31	72. 79	3. 826	12. 93	G. W. Dean, R. E. Halter, and A. D. Bache.	Do.

## DAKOTA TERRITORY.

14. 00	72. 85	4. 13	14. 01	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 91	74. 91	3. 62	13. 91	Do.	Do.
13. 90	75. 58	3. 46	13. 90	Do.	Do.
13. 97	77. 44	3. 03	13. 93	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
DELAWARE.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Dagsborough.	38 35.0	75 15.6	1856	Aug. 28.	71 03.1	4. 348
Pilot-town.	38 47.1	75 09.5	1846	July 2.	71 18.5	4. 290
Cape Henlopen Light-House.	38 46.5	75 05.3	1856	Aug. 27.	71 22.0	4. 285
Bombay Hook.	39 21.8	75 30.7	1846	June 17.	71 39.5	4. 201
Delaware City.	39 35	75 36	1842	----	71 46	----
Fort Delaware.	39 35.3	75 34.2	1846	June 14, 15.	71 34.9	4. 226
Sawyer.	39 42.1	75 34.0	1846	June 3.	71 57.5	4. 175
Wilmington.	39 44.9	75 33.9	1846	May 28.	71 25.4?	4. 236
Do.	39 46.6	75 32.5	1875	July 17, 22; Oct. 4.	71 24.0	4. 364

## DISTRICT OF COLUMBIA.

Washington.	38 53.5	77 01	1838	----	71 13	----
Washington, park fronting Capitol.	38 53.5	77 00.5	1839	Feb.	71 17.5	----
Washington, front of the Capitol.	38 53.5	77 00.5	1839	Sept.	71 21.4	----
Washington, north of Capitol.	38 53.6	77 00.6	{ 1840 1841 }	----	71 20.2	----
Washington, east of the Capitol.	38 53.5	77 00.5	1841	June and Aug.	71 15.2	----
Do.	38 53.5	77 00.5	1841	July.	71 14.4	----
Washington, Capitol Hill.	38 53.4	77 00.5	1841	Sept.	71 15.9	----
Washington, north of Capitol.	38 53.6	77 00.6	{ 1841 1842 }	----	71 18.0	----
Washington, park east of Capitol.	38 53.4	77 00.5	1842	----	71 13.1	----
Washington, grounds west of Capitol.	38 53.4	77 00.8	1842	Oct. 10.	71 13.8	4. 316
Washington, near War Department.	38 53.9	77 02.4	1843	Jan.	----	4. 320
Washington, Gilliss' Magnetic Observatory, north of Capitol.	38 53.6	77 00.6	1844	Apr. 6.	71 39.3	4. 277
Washington, old depot near Georgetown.	38 53.7	77 03	1844	Apr. 8.	71 34.8	4. 274
Washington, west and east sides Capitol grounds.	38 53.4	77 00.7	1844	Apr. 9.	71 13.4	4. 309
Washington, near Patent Office.	38 53.9	77 01.4	1844	Apr. 10.	71 15.0	4. 289
Washington, near War Department.	38 53.9	77 02.4	1844	Apr. 11.	71 20.5	4. 307
Washington, near Capitol, east side.	38 53.5	77 00.5	1844	July.	71 10.6	----
Washington, near old Coast Survey Office, south of Capitol.	38 53.1	77 00.6	1845	{ Jan. to May and Nov. }	71 33.9	{ 4. 240 4. 233 }
Washington, northwest of the Capitol.	38 53.6	77 01.0	1852	May, June.	71 16.1	4. 267
Washington, near White House and Navy Department.	38 53.5	77 02	1853	May 28.	71 21.4	----
Washington, grounds of Smithsonian Institution	38 53.2	77 01.6	1855	July, Sept.	71 27.0	4. 337
Washington, grounds east of Capitol.	38 53.3	77 00.5	1856	Aug. 15.	71 19.6	4. 308
Washington, near old Coast Survey Office, south of Capitol.	38 53.1	77 00.6	1856	Aug., Sept.	71 21.7	4. 308
Do.	38 53.1	77 00.6	1857	Mar.	71 22.5	----

*intensities in the United States and adjacent regions.—Continued.*

## DELAWARE.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
13. 39	70. 45	4. 434	13. 25	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 39	70. 80	4. 355	13. 24	J. Locke.	Do.
13. 41	70. 77	4. 371	13. 27	C. A. Schott.	Do.
13. 35	71. 15	4. 266	13. 20	J. Locke.	Do.
----	71. 25	----	----	Barnett.	Phil. Trans. R. S., 1875.
13. 38	71. 07	4. 291	13. 23	J. Locke.	C. & G. S. Rpt., 1881, App. 9.
13. 48	71. 45	4. 240	13. 33	Do.	Do.
----	70. 96	4. 352	13. 34	Do.	C. & G. S. Rpt., 1881, App. 9. Also $\theta=72^{\circ} 24'.5$ ; local disturbance at this place.
13. 68				J. M. Poole.	C. & G. S. Rpt., 1881, App. 9. Local disturbance at this place.

## DISTRICT OF COLUMBIA.

----			C. Wilkes.	Sill. J., Vol. XXXIX, 1840.
----			C. Wilkes and E. Loomis.	Sill. J., Vol. XLIII, 1842.
----			E. Loomis.	Sill. J., Vol. XXXIX, 1840.
----			J. M. Gilliss.	Sill. J., Vol. I, 1846.
----			J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, 1843.
----			J. D. Graham and J. N. Nicollet.	Do.
----			A. D. Bache.	C. S. Rpt., 1862, App. 19.
----			J. M. Gilliss.	Sill. J., Vol. I, 1846.
----			J. D. Graham.	Sill. J., Vol. IV, 1847.
13. 414			J. H. Lefroy.	Diary Mag. Sur. Canada, London, 1883.
----			A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 59			J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 53			Do.	Do.
13. 39			Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. Same results for W. & E. sides.
13. 35			Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 47			Do.	Do.
----			J. D. Graham.	Am. Phil. Soc., Vol. VII, 1844.
13. 41	}		T. J. Lee.	C. & G. S. Rpt., 1881, App. 9.
13. 39			J. E. Hilgard.	Do.
13. 29			J. M. Gilliss.	U. S. Ast. Expedition to Chili, Vol. VI.
----			C. A. Schott.	C. & G. S. Rpt., 1881, App. 9. Locality affected by local disturbance.
13. 45			Do.	C. & G. S. Rpt., 1881, App. 9.
13. 48			Do.	Do.
----			W. Reed.	C. S. Rpt., 1858, App. 26.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DISTRICT OF COLUMBIA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Washington, near old Coast Survey Office, south of Capitol.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1858	June 2.	$71^{\circ} 22' 6''$	4. 255
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1859	June and July.	$71^{\circ} 24' 4''$	4. 307
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1860	Aug. and Sept.	$71^{\circ} 15' 9''$	4. 319
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1861	----	$71^{\circ} 18' 3''$	----
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1862	July, Aug., Sept.	$71^{\circ} 18' 5''$	4. 284
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1863	July 18-28.	$71^{\circ} 14' 3''$	4. 294
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1865	June 27.	$71^{\circ} 11' 7''$	----
Washington, grounds United States Naval Ob- servatory.	$38^{\circ} 53' 7''$	$77^{\circ} 03' 1''$	1866	Nov. 1.	$72^{\circ} 02' (?)$	4. 300
Do.	$38^{\circ} 53' 7''$	$77^{\circ} 03' 1''$	1867	May 6.	$71^{\circ} 58'$	----
Washington, near old Coast Survey Office, south of Capitol.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 6''$	1867	May 6.	$71^{\circ} 26'$	----
Washington, magnetic observatory, Schott's garden, corner Second and C streets south- east.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1867	Jan. to Dec.	$71^{\circ} 06' 7''$	4. 321
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1868	Jan. to Dec.	$71^{\circ} 03' 4''$	4. 334
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1869	May 15.	$71^{\circ} 19' 2''$	----
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1869	Jan. to July.	$70^{\circ} 57' 9''$	4. 347
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1870	June 13, 14, 15.	$70^{\circ} 55' 3''$	4. 352
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1871	June 14, 15, 16.	$70^{\circ} 59' 9''$	4. 356
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1872	June 14, 15, 17.	$71^{\circ} 00' 6''$	4. 360
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1873	June 14, 16, 17.	$70^{\circ} 58' 5''$	4. 344
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1874	June 13, 15, 16.	$70^{\circ} 52' 4''$	4. 349
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1875	June 12, 14, 15.	$70^{\circ} 51' 0''$	4. 353
Do.	$38^{\circ} 53' 1''$	$77^{\circ} 00' 2''$	1876	May 1, 2.	$70^{\circ} 47' 3''$	$\left\{ \begin{array}{l} 4. 357 \\ 4. 356 \end{array} \right\}$
Washington magnetic observatory, Schott's gar- den, near corner First and B streets southeast.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1877	$\left\{ \begin{array}{l} \text{June 14, 15, 16.} \\ \text{Aug. and Dec.} \end{array} \right\}$	$\left\{ \begin{array}{l} 70^{\circ} 49' 1'' \\ 70^{\circ} 49' 1'' \end{array} \right\}$	$\left\{ \begin{array}{l} 4. 366 \\ 4. 373 \end{array} \right\}$
Do.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1878	June, Sept., Dec.	$\left\{ \begin{array}{l} 70^{\circ} 49' 3'' \\ 70^{\circ} 46' 9'' \end{array} \right\}$	$\left\{ \begin{array}{l} 4. 368 \\ 4. 361 \\ 4. 374 \end{array} \right\}$
Do.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1879	June 9, 10, 11.	$70^{\circ} 48' 4''$	4. 370
Do.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1880	$\left\{ \begin{array}{l} \text{June 12-17.} \\ \text{July 9, 10, 12.} \end{array} \right\}$	$\left\{ \begin{array}{l} 70^{\circ} 46' 4'' \\ 70^{\circ} 43' 4'' \end{array} \right\}$	$\left\{ \begin{array}{l} 4. 378 \\ 4. 372 \end{array} \right\}$
Do.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1881	April 26.	----	4. 380
Do.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1881	June 25, Dec. 17, 23.	$70^{\circ} 42' 8''$	----
Do.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1882	$\left\{ \begin{array}{l} \text{May.} \\ \text{June 15, 16, 17.} \\ \text{Sept. and Oct.} \end{array} \right\}$	$\left\{ \begin{array}{l} 70^{\circ} 47' 8'' \\ 70^{\circ} 44' 1'' \\ 70^{\circ} 45' 2'' \end{array} \right\}$	$\left\{ \begin{array}{l} 4. 364 \end{array} \right\}$
Do.	$38^{\circ} 53' 2''$	$77^{\circ} 00' 4''$	1883	June 18, July 5.	$70^{\circ} 40' 8''$	4. 373

*intensities in the United States and adjacent regions.—Continued.*

## DISTRICT OF COLUMBIA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°			C. A. Schott.	C. & G. S. Rpt., 1881, App. 9; E. K. Kane's Mag. Obs's, Smithsonian Cont's to Know.
13. 51				Do.	C. & G. S. Rpt., 1881, App. 9.
13. 446				Do.	Do.
----				S. Walker.	Do.
13. 368				C. A. Schott.	Do.
13. 351				Do.	Do.
----				Do.	Do.
13. 93				W. Harkness.	Smithsonian Cont's to Know., No. 239, Wash., 1873. Dip apparently 1° too great; hence also F too great.
----				Do.	MS. in C. & G. S. Office.
----				Do.	Do.
13. 347	70 55	4. 395	13. 20	C. A. Schott and E. Goodfellow.	C. & G. S. Rpt., 1881, App. 9.
13. 350				C. A. Schott.	Do.
----				A. Hall.	MS. in C. & G. S. Office.
13. 328				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 315				Do.	Do.
13. 378				Do.	Do.
13. 399				Do.	Do.
13. 326				Do.	Do.
13. 272				Do.	Do.
13. 270				Do.	Do.
13. 238				{ C. A. Schott and F. E. Hilgard. }	Do.
13. 292				C. A. Schott and A. Braid.	Do.
13. 282 } 13. 248 }				{ C. A. Schott, T. E. Thorpe, and J. B. Baylor. }	C. & G. S. Rpt., 1881, App. 9. For Dr. Thorpe's results see Proc. R. S., No. 200, 1880.
13. 292				W. Eimbeck and C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 258 } 13. 275 }				J. B. Baylor.	Do.
----				Do.	Do.
----				S. W. Very.	Do.
13. 227				B. A. Colonna, W. Eimbeck.	C. & G. S. Rpt., 1881, App. 9, and MS. in C. & G. S. Office.
13. 218				C. A. Schott.	MS. in C. & G. S. Office.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DISTRICT OF COLUMBIA—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip δ.	Horizontal force H.
Washington, magnetic observatory, Schott's garden, near corner of First and B streets southeast.	38 53.2	77 00.4	1884	Jan. and Feb.	70 37.3 70 40.0	4.375
Do.	38 53.2	77 00.4	1884	June 16, 17.	70 33.2	4.396
Do.	38 53.2	77 00.4	1885	June 13, 15.	70 32.9	4.397
Georgetown, West Washington.	38 54	77 03	1844	Apr. 10.	71 19.0	4.277
Causten, Georgetown Heights.	38 55.5	77 04.5	1851	June 9, 23.	71 18.9	4.233
Do.	38 55.5	77 04.4	1855	Sept. 8.	71 30.2	4.250

## FLORIDA.

Sand Key, Florida Reef.	24 27.2	81 52.7	1849	Aug. 18, 19, 22.	54 25.8	6.758
Key West, magnetic observatory.	24 33.1	81 48.5	1860	Feb., Mar., June, Dec.	54 37.8	6.752
Do.	24 33.1	81 48.5	1861	Feb., Mar., Apr.	54 36.8	6.749
Do.	24 33.1	81 48.5	1862	May to Dec.	54 31.0	6.742
Do.	24 33.1	81 48.5	1863	Jan. to Dec.	54 31.2	6.740
Do.	24 33.1	81 48.5	1864	Jan. to Dec.	54 29.0	6.738
Do.	24 33.1	81 48.5	1865	Jan. to Dec.	54 28.8	6.729
Do.	24 33.1	81 48.5	1866	Jan. to Apr.	54 28.6	6.725
Key West, grounds of Army Hospital.	24 33.3	81 47.9	1879	Mar. 24, 25; May 7	54 28.6	6.632
Bird Key.	24 37.3	82 53.6	1880	Jan. 12, 13, 14.	54 12.6	6.691
Cape Florida.	25 40.4	80 09.8	1850	Feb. 22, 23, 26.	56 13.0	6.615
Hills, Hillsboro' River.	26 15.5	80 04.7	1884	Jan. 23.	57 01.6	----
Punta Rasa.	26 29.3	82 00.6	1866	June 28; July 2.	57 12.3	6.583
Fort Jupiter, $\frac{3}{4}$ of a mile southeast of light-house.	26 54.5	80 05	1880	Mar. 8.	57 38.5	6.278
House of Refuge No. 2, Indian River.	27 12.0	80 09.8	1883	Mar. 24.	57 43.8	6.245
Bell, Indian River.	27 27.9	80 19.6	1883	May 6.	58 00.9	6.323
Saint Lucie, on beach of Indian River.	27 28.9	80 15	1880	Mar. 2.	58 16.8	6.297
Eau Gallie, old agricultural college.	28 09.4	80 37	1880	Feb. 25.	58 52.1	6.248
Enterprise, rear of village.	28 52.9	81 14	1880	Feb. 18.	60 07.5	6.053
Depot Key, Cedar Keys.	29 07.5	83 02.1	1852	Mar. 14-24.	59 55.3	6.179
Apalachicola.	29 43.2	84 59.0	1860	Jan. 26; Feb. 4.	60 19.4	6.185
Saint Augustine, Government reservation.	29 54	81 19	1880	Feb. 11.	61 09.2	5.925
Jacksonville, hill north of town.	30 21	81 40	1880	Feb. 3.	61 43.2	5.857
Pensacola, public square.	30 24.6	87 12.9	1858	June 22, 23.	61 05.9	6.127
Pensacola, near Barkley station.	30 24.6	87 12.5	1861	Jan. 5-11.	60 38.9	6.151
Fernandina, geodetic station.	30 40.6	81 27.6	1857	Apr. 6, 10, 20.	62 07.3	5.889
Fernandina, Indian mound.	30 40.3	81 27.3	1879	Feb. 3-12.	61 53.6	5.858
Tallahassee.	30 26	84 17	1835	Jan.	61 23	----

*intensities in the United States and adjacent regions.—Continued.*

## DISTRICT OF COLUMBIA.—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885-0}$	$H_{1885-0}$	$F_{1885-0}$		
13. 185	70 83	4. 327	13. 18	{ J. E. Maxfield and W. Eimbeck.	MS. in C. & G. S. Office.
13. 204				C. A. Schott.	Do.
13. 205				Do.	Do.
13. 36				J. Locke.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke, papers of 1844.
13. 21				G. W. Dean and A. D. Bache.	C. & G. S. Rpt., 1881, App. 9.
13. 40				C. A. Schott.	Do.

## FLORIDA.

11. 62	54. 33	6. 73	11. 54	J. E. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
11. 665	54. 43	6. 628	11. 40	W. P. Trowbridge and S. Walker.	C. S. Rpt., 1874, App. 9.
11. 650				S. Walker and J. G. Oltmanns.	Do.
11. 620				S. Walker, J. G. Oltmanns, and F. F. Nes.	Do.
11. 612				S. Walker.	Do.
11. 598				Do.	Do.
11. 582				Do.	Do.
11. 569				Do.	Do.
11. 41				S. M. Ackley.	C. & G. S. Rpt., 1881, App. 9.
11. 44	54. 21	6. 688	11. 44	Do.	Do.
11. 90	56. 12	6. 59	11. 82	J. E. Hilgard.	Do.
----	57. 03	----	----	B. A. Colonna.	MS. in C. & G. S. Office.
12. 15	57. 11	6. 57	12. 10	A. T. Mosman.	C. & G. S. Rpt., 1881, App. 9.
11. 73	57. 64	6. 275	11. 72	J. B. Baylor.	Do.
11. 70	57. 73	6. 244	11. 69	B. A. Colonna.	MS. in C. & G. S. Office.
11. 94	58. 01	6. 322	11. 93	Do.	Do.
11. 98	58. 28	6. 294	11. 97	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
12. 08	58. 87	6. 245	12. 08	Do.	Do.
12. 15	60. 12	6. 050	12. 14	Do.	Do.
12. 33	59. 83	6. 16	12. 26	J. E. Hilgard.	Do.
12. 49	60. 22	6. 17	12. 42	G. W. Dean.	Do.
12. 28	61. 15	5. 923	12. 28	J. B. Baylor.	Do.
12. 36	61. 72	5. 855	12. 36	Do.	Do.
12. 68	60. 80	6. 13	12. 57	J. G. Oltmanns and F. H. Gerdes.	Do.
12. 55				G. W. Dean.	Do.
12. 59	61. 93	5. 87	12. 48	C. A. Schott.	Do.
12. 43				S. M. Ackley.	Do.
----	61. 30	----	----	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
GEORGIA.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Du Pont or Lawton, east of depot.	30 57.8	82 47	1880	Jan. 29.	62 07.3	5.841
Butler.	31 17.7	81 20.8	1872	Mar. 12-18; Apr. 15, 16.	62 46.7	5.779
Tybee Light-House.	32 01.5	80 50.7	1852	Apr. 30; May 1, 2.	63 40.8	5.618
Do.	32 01.5	80 50.7	1870	May 21-26.	63 27.0	5.682
Savannah, Hutchinson's Island opposite city.	32 05.2	81 05.3	1852	Apr. 24-27.	63 40.0	5.625
Do.	32 05.2	81 05.3	1857	May 1, 2.	63 44.3	5.664
Do.	32 05.2	81 05.3	1874	Mar. 5-10.	63 53.9	5.558
Macon (Bibb County) Academy.	32 50.4	83 37.5	1855	Jan. 10-16.	63 50.9	5.660
Augusta.	33 28	81 34	1833	Feb.	---	5.679
Middle Base, near Atlanta.	33 54.4	84 16.7	1872	Oct., Nov.	64 55.6	5.507
Do.	33 54.4	84 16.7	1873	Feb. 8-13.	64 58.5	5.489
Athens.	33 57	83 25	{ 1833 1834	{ May. Sept. }	65 40	4.568
Kenesaw, about one-half mile east of geode- tic station.	33 58.6	84 34.8	1873	Aug. 1, 2, 3.	66 00.2	5.424
Carnes, on a ridge south side of mountain.	33 59.6	85 00.8	1873	Dec. 20, 21, 22.	65 09.6	5.468
Sweat, foot of mountain.	34 04.0	84 27.4	1873	Oct. 9, 10.	65 29.2	5.455
Cumming, northeast part of town.	34 12.4	84 07.7	1873	Nov. 10-18.	65 23.5	5.461
Sawnee, summit of mountain.	34 14.2	84 09.7	1873	Nov. 1-14.	65 26.0	5.412
Pine Log, near geodetic station.	34 19.3	84 38.3	1874	Aug. 10, 11, 12.	65 33.0	5.422
Lavender, near geodetic station.	34 19.3	85 17.4	1874	Dec. 10, 11, 12.	65 30.7	5.430
Grassy, near geodetic station.	34 29.2	84 20.0	1874	July 24-31.	65 41.8	5.192
Currahee, south end of ridge on summit.	34 31.8	83 22.6	1874	Oct. 26, Nov. 11.	65 45.1	5.282
Johns, about two miles north of geodetic station.	34 37.4	85 06.0	1875	June 22, 23, 24.	65 42.5	5.401

## IDAHO TERRITORY.

Lewiston, Montgomery street, near Presby- terian church.	46 28	117 05	1881	Sept. 16, 17, 18.	70 52.0	4.275
Lake Pend d'Oreille Landing.	47 58	116 30	1881	Sept. 10, 11.	72 26.0	4.006
Sinyakwateen. *	48 09	116 44	1860	----	----	3.991
Do.	48 09	116 44	1861	May 31.	72 34.9	4.0125
Siniaquoteen,* near store-house.	48 10.5	116 45	1881	Sept. 5, 6.	72 30.7	3.969
Pack River.	48 22	116 28	1861	June 19.	72 45.5	3.9683
Chelemta River.	48 41	116 19	1861	June 23.	73 08.0	3.9116
Chelemta Depot.	48 41	116 19	1861	----	73 06	3.902

## ILLINOIS.

Cairo.	37 00	89 10	1856	Dec. 13.	68 13	5.081
Do.	37 00	89 10	1872	June 22.	67 41.3	4.914
Cairo, northwest of astronomical station.	37 01.0	89 10.5	1877	Nov. 28, 30.	67 45.6	5.058

\* Spelling unsettled.

*intensities in the United States and adjacent regions.—Continued.*

## GEORGIA.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
12. 49	61. 96	5. 841	12. 43	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
12. 63	62. 46	5. 78	12. 50	A. T. Mosman.	Do.
12. 67	} 63. 20	5. 65	12. 53 {	J. E. Hilgard.	Do.
12. 71				C. O. Boutelle.	Do.
12. 68	} 63. 41	5. 62	12. 56 {	J. E. Hilgard.	Do.
12. 80				C. A. Schott.	Do.
12. 63				C. Tappan and F. Blake.	Do.
12. 84	63. 45	5. 68	12. 71	G. W. Dean.	Do.
----	----	----	----	J. N. Nicollet.	C. S. Rpt., 1864.
13. 00	} 64. 63	5. 50	12. 84 {	F. P. Webber.	C. & G. S. Rpt., 1881, App. 9.
12. 98				Do.	Do.
----	65. 25	----	----	J. N. Nicollet.	{ C. S. Rpt., 1864, App. 19. The dip is the mean of 3 det's corrected for index error, value of H mean of 3 det's. Epoch 1834.3 .
13. 34	65. 69	5. 44	13. 21	F. P. Webber.	
13. 02	64. 85	5. 49	12. 92	Do.	Do.
13. 15	65. 18	5. 47	13. 03	Do.	Do.
13. 11	65. 08	5. 47	12. 98	H. W. Blair and C. O. Boutelle.	Do.
13. 02	65. 12	5. 42	12. 88	C. O. Boutelle.	Do.
13. 10	65. 25	5. 43	12. 97	F. P. Webber.	Do.
13. 10	65. 21	5. 44	12. 97	Do.	Do.
12. 62	65. 40	5. 20	12. 49	C. O. Boutelle.	Do.
12. 86	65. 45	5. 29	12. 73	Do.	Do.
13. 13	65. 43	5. 41	13. 01	F. P. Webber.	Do.

## IDAHO TERRITORY.

13. 04	70. 84	4. 27	13. 01	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
13. 27	72. 40	4. 00	13. 23	Do.	Do.
----	} 72. 48	3. 96	13. 16 {	J. S. Harris.	U. S. N. W. Bound. Com. MS. in C. & G. S. Office.
13. 370				R. W. Haig.	Bound. Sur., Phil. Trans. R. S., 1864. $\theta, H$ & $F$ obs'd.
13. 21	} 72. 7	----	----	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
13. 391				R. W. Haig.	Bound. Sur., Phil. Trans. R. S., 1864. $\theta, H$ & $F$ obs'd.
13. 469	} 73. 1	----	----	Do.	Do.
----				J. S. Harris.	U. S. N. W. Bound. Com. MS. in C. & G. S. Office.

## ILLINOIS.

13. 693	} 67. 44	5. 06	13. 19 {	K. Friesach.	Acad. Sc., Vienna, Vol. 29, 1858.
----				T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
13. 36				A. Braid.	C. & G. S. Rpt., 1881, App. 9.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

ILLINOIS—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Golconda.	37 23	88 25	1871	Aug., Oct.	68 03.1	----
Do.	37 23	88 25	1872	June 6-17.	67 55.9	4. 885
East Saint Louis, grove opposite Bloody Island.	38 37.5	90 11	1841	Oct. 6.	69 26.7	----
Collinsville.	38 39	90 04	1879	Sept. 13.	69 38.2	4. 633
Highland, Commons south of depot.	38 45	89 41	1872	Sept. 3.	69 47.2	4. 626
Edwardsville, west of Court-House.	38 50	89 53	1841	Sept.	69 57.7	----
Alton, half mile from landing.	38 54	90 04	1841	Sept.	69 34.8	----
Upper Alton, east of college.	38 55	90 03	1841	Sept.	69 45.7	----
Monticello, near the Seminary.	38 57	90 05	1841	Sept.	69 38.9	----
Bunker Hill, one mile north of village.	39 04	89 53	1841	Sept.	69 49.1	----
Macon, pasture east of place of R. H. Woodcock.	39 42	89 10	1872	Sept. 1.	70 13.5	4. 475
Springfield, grounds of Lincoln Monument.	39 50	89 39	1878	Dec. 3-7.	70 25.5	4. 497
Beardstown.	40 00	90 29	1880	Aug. 9.	70 18.6	4. 476
Copperas Creek, mouth of.	40 30	89 48	1841	Sept.	70 56.4	----
Pekin, near steamboat landing.	40 35	89 36	1841	Sept.	71 13.2	----
Wenona, grounds of J. R. Cowen.	41 05	89 26	1872	Aug. 29, 30.	71 43.9	4. 241
Ottawa, one-quarter mile west of town, near bridge.	41 15	88 50	1841	Sept.	72 20.2	----
Peru, lower end of town, right bank of river.	41 20	89 03	1841	Sept.	71 49.6	----
Peru, near landing.	41 23	89 05	1841	Sept.	71 51.1	----
Joliet, oak grove near church on hill.	41 30	88 09	1841	Sept.	72 16.0	----
Rock Island, near astronomical post.	41 31.1	90 33.7	1878	Sept. 15-20; Oct. 5, 7.	72 15.3	4. 2079
Mount Forest, near astronomical post.	41 44.7	87 51.9	1876	Aug. 29; Sept. 2.	71 52.8	3. 9713
Chicago, north side of Chicago River, near lake.	41 53	87 38	1841	Sept.	72 45.8	----
Chicago, one mile north of town.	41 53	87 38	1841	Sept.	72 47.8	----
Chicago, Dr. Eldridge's garden.	41 53	87 38	1842	Nov. 15, 16.	72 39.3	4. 105
Chicago, grounds of Chicago University.	41 50.0	87 36.7	1878	Sept. 2.	72 39.4	4. 067
Rockford, near park.	42 17.0	89 06.6	1876	Oct. 6-11.	72 48.3	4. 0827
Galena, near astronomical post.	42 25.2	90 25.9	1876	Sept. 28, 29.	73 09.0	3. 9926
Galena, hill back of town.	42 28	90 26	1841	Sept.	73 02.1	----
Dunleith.	42 28	90 40	1856	Oct. 18.	73 10	----

## INDIANA.

Mount Vernon.	37 59	87 47	1840	Sept. 10.	68 56.3	4. 841
New Harmony.	38 10	87 48	1840	Sept. 11.	69 03.6	4. 812
Do.	38 08	87 50	1848	Nov. 12, 13.	69 07.2	4. 843
New Harmony, center of common, Main street.	38 08	87 50	1880	Nov. 3, 5.	69 02.6	4. 762
New Albany, on hill in cemetery.	38 20	85 47	1871	Nov. 28.	70 21.9	4. 466
Princeton.	38 23	87 30	1840	Sept. 16.	69 22.8	4. 751
Paoli.	38 35	86 25	1840	Sept. 20.	69 33.8	4. 692

*intensities in the United States and adjacent regions.—Continued.*

## ILLINOIS—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°				
----	67.66	4.89	12.87	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
----				Do.	Do.
----	69.10	----	----	J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, 1843.
----	69.46	4.63	13.20	F. E. Nipher.	St. Louis Acad. Sc.
----	69.47	4.63	13.20	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
----	69.61	----	----	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----					
----	69.31	----	----	Do.	Do.
----					
----	69.47	----	----	Do.	Do.
----	69.91	4.48	13.05	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
13.42	70.22	4.50	13.29	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----	70.16	4.48	13.20	F. E. Nipher.	St. Louis Acad. Sc.
----	70.59	----	----	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----	70.87	----	----	Do.	Do.
----	71.41	4.24	13.30	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
----	71.99	----	----	J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, 1843.
----					
----	71.49	----	----	Do.	Am. Phil. Soc., Vol. VIII, 1843.
----				E. Loomis.	Do.
----	71.92	----	----	J. N. Nicollet.	Do.
13.806	72.05	4.21	13.66	C. F. Powell.	Rpt. Chief of Engineers, U. S. A., 1877, pt. 2.
12.770	71.62	3.97	(12.59)	D. W. Lockwood.	Do.
----				J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, pt. 3, 1843.
----				E. Loomis.	Do.
13.778	72.41	4.07	13.48	C. Younghusband.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ H F obs'd.
13.644				T. E. Thorpe.	Proc. R. S., No. 200, 1880.
13.810	72.54	4.08	13.60	C. F. Powell.	Rpt. Chief of Engineers, U. S. A., 1877, pt. 2.
13.774				Do.	Rpt. Chief of Engineers, U. S. A., 1877, pt. 2. Local disturbance suspected.
----	72.79	3.99	13.49	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----				K. Friesach.	Acad. Sc. Vienna, Vol. XXIX, 1858.
----	72.77	----	----		

## INDIANA.

13.47	68.59	----	----	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13.47				Do.	Do.
13.59	68.79	4.76	13.16	R. H. Fauntleroy.	C. & G. S. Rpt., 1881, App. 9.
13.31				J. B. Baylor.	Do.
----	70.01	4.47	13.08	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13.49	69.03	----	----	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13.44	69.21	----	----	Do.	Do.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

INDIANA—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Vincennes.	38 40.6	87 31.5	1840	Sept. 18.	69 51.2	4.665
Vincennes, ½ mile above lower ferry.	38 40.6	87 31.5	1841	Oct.	69 52.8	----
Vincennes, southwest corner of Catholic cemetery.	38 41.7	87 31.6	1880	Oct. 29, 30.	69 50.4	4.632
Terre Haute.	39 28	87 20	1874	Aug. 29.	70 34.7	4.505
Indianapolis, fair grounds north of city.	39 47.4	86 08	1880	Nov. 12, 13.	70 51.4	4.370
Richmond.	39 49	84 47	1845	----	71 20.3	----
Richmond, Front street.	39 50	84 50	1871	Nov. 24.	71 26.6	----
Richmond, Court House Square.	39 50.4	84 50	1880	Nov. 19, 20.	71 13.4	4.354
Reynolds.	40 45	86 48	1874	Aug. 27.	72 00	4.212
Fort Wayne, in fair grounds.	41 06.3	85 03	1874	Aug. 24.	72 19.0	4.218
Michigan City, near light-house.	41 43	86 54	1859	Aug. 28.	73 02	4.013
Michigan City, on beach near light-house.	41 43	86 54	1873	Aug. 25, 26.	72 43	4.091

## INDIAN TERRITORY.

Atoka, north of and near J. Harden's house.	34 24.5	96 05	1878	July 13-17.	63 44.8	5.670
Vinita, on premises of Dr. Trott.	36 39.5	95 05.0	1877	Nov. 22, 23, 24.	66 31.8	5.284
Vinita.	36 41.4	95 07.1	1878	Sept. 9.	66 39.5	4.936

## IOWA.

Keokuk, corner of Second and Blondeau streets.	40 25.5	91 25.0	1877	Nov. 6, 7, 8.	70 47.2	4.506
Keokuk.	40 24.8	91 28.0	1878	July 29, 30, 31.	70 46.7	4.419
Council Bluffs, near railroad depot.	41 15.3	95 52.4	1878	Aug. 30.	71 05.7	4.3663
Engineer cantonment.	41 25	95 44	1820	----	71 07	----
Davenport.	41 30	90 38	1839	Sept. 13.	71 55	4.278
Do.	41 30	90 40	1839	Sept. 15.	71 55.2	4.269
Davenport, near corner of Seventh and Scott streets.	41 29.9	90 38.0	1877	Oct. 27-30.	71 56.6	4.274
Des Moines.	41 35.0	94 37.4	1869	Aug. 9.	71 13	4.313
Des Moines, Chestnut street between Fifth and Sixth.	41 35	93 37	1872	Nov. 4.	71 30.4	4.228
Des Moines, corner Ninth and Sycamore streets.	41 36.8	93 36.5	1877	Oct. 23, 24, 25.	71 31.0	4.330
Lost Grove.	41 39	90 09	1839	Sept. 23.	72 02.4	4.260
Iowa City, Nipher's farm, 4 miles west.	41 39.7	91 35.5	1878	June 16.	72 02.8	----
Iowa City, grounds of University.	41 39.7	91 31.5	1878	July 2-7.	72 19.7	4.118
Iowa City, Nipher's farm, 4 miles west.	41 39.7	91 35.5	1879	July 6, 7-11.	72 02.7	4.128

*intensities in the United States and adjacent regions.—Continued.*

## INDIANA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13.55	0			J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	69.57	4.63	13.27	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
13.44				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----	70.28	4.51	13.37	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13.33	70.71	4.37	13.23	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----	71.06	4.35	13.40	J. Locke.	Phil. Trans. R. S., 1846.
----				T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13.53	71.70	4.21	13.41	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----				F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	72.02	4.22	13.67	Do.	Do.
13.789	72.52	4.09	13.62	W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, Detroit, 1859, and Rpt. of 1882.
13.770				A. N. Lee.	U. S. Lake Sur., Rpt. of 1882.

## INDIAN TERRITORY.

12.82	63.64	5.67	12.77	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13.27	66.47	5.11	12.80	A. Braid.	Do.
----				F. E. Nipher.	St. Louis Acad. Sci.

## IOWA.

13.69	70.72	4.46	13.51	A. Braid.	C. & G. S. Rpt., 1881, App. 9.
----				F. E. Nipher.	St. Louis Acad. Sc.
13.476	71.09	4.37	13.49	T. E. Thorpe.	Proc. R. S., No. 200, 1880.
----				S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill, J., Vol. XXXIV, 1838.
13.78	71.9	4.27	13.74	J. Locke.	Sill, J., 1840; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's papers of 1844.
13.76				Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's papers of 1844.
13.79	71.44	4.33	13.61	A. Braid.	C. & G. S. Rpt., 1881, App. 9.
13.40				J. E. Hilgard.	Do.
----	71.9	----	----	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14., Nat. Acad. Ser.
13.66				A. Braid.	C. & G. S. Rpt., 1881, App. 9.
13.81	72.07	4.13	13.42	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----				F. E. Nipher.	St. Louis Acad. Sc.
----					Do.
----					MS. dated July 19, 1879, in C. & G. S. Office.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
IOWA—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Wapsipinicon.	41 44	90 23	1839	Sept. 25.	72 15.0	4.234
Iron Ore Bed.	41 55	90 40	1839	Sept. 27.	72 50.5	4.135
Brown's Settlement.	42 02	91 06	1839	Sept. 30.	72 21	4.179
Iowa Station.	42 04	91 02	1839	----	72 24.4	----
Farmer's Creek.	42 13	90 23	1839	Oct. 5.	72 36	4.162
Maquoketa River.	42 14	90 55	1839	Oct. 2.	72 43.6	4.112
White Water.	42 18	90 38	1839	Oct. 8.	72 55	4.063
Maquoketa, north branch.	42 23	90 52	1839	Oct. 9.	72 51	4.049
Dubuque.	42 29	90 40	1839	Oct. 14.	73 05	4.008
Dubuque, on Seminary Hill.	42 30	90 45	1872	Aug. 24-27.	73 06.8	3.933
Dubuque.	42 29.5	90 44	1880	Oct. 21, 22.	73 07.8	3.972
Forks of Little Maquoketa.	42 31	90 31	1839	Oct. 20.	73 08	4.011
Turkey River.	42 42	90 48	1839	Oct. 22.	73 11	3.974
Sibley, yard of Sibley House.	43 24.1	95 50.0	1877	Oct. 8, 9, 10.	72 59.3	4.053

## KANSAS.

Parsons.	37 20.0	95 17.4	1879	Aug. 26.	67 12.4	5.080
Sargent, north of railroad, west of Hardesty House.	38 05.2	101 58.5	1878	Aug. 8-10-12.	66 50.5	5.129
Great Bend, west of school-house.	38 23.6	98 43.1	1878	July 30, 31, Aug. 1, 2.	67 38.0	4.988
Wallace.	38 55	101 35	1872	Oct. 12.	67 31.6	4.956
Ellis.	38 56	99 40	1872	Oct. 10.	67 51.7	4.934
Lawrence, grounds of Old University.	38 57.7	95 15.0	1877	Nov. 14-17.	68 43.4	4.866
Manhattan, College grounds.	39 12	96 35	1872	Oct. 7.	68 47.2	4.773
Fort Leavenworth.	39 21	94 54	1858	----	69 29	----
Little Muddy Creek.	39 35	95 34	1858	----	69 35	----
Vermillion Creek.	39 57	96 16	1858	----	70 09	----
Big Blue River.	40 00	96 35	1858	----	69 19	----

## KENTUCKY.

Hickman, court-house grounds.	36 34.3	89 11.7	1881	Sept. 23, 24.	67 19.4	5.071
Mayfield, court-house square.	36 45	88 41	1881	Sept. 27, 28.	67 35.0	5.008
Williamsburg, court-house place.	36 47	84 10	1873	Aug. 14.	68 25.7	4.933
Oakland, near astronomical station.	37 02.4	86 15.3	1871	Nov. 6, 10.	68 48.8	4.877
Smithland.	37 08	88 30	1833	Dec.	68 11	----
Mammoth Cave, at the mouth, near house.	37 10	86 11	1849	June 14.	69 18.5	----
Madisonville, court-house square.	37 19	87 33	1881	Oct. 4, 5.	68 24.2	4.915
Livingston, meadow west of Sand Brook Hotel	37 23	84 20	1881	Oct. 20, 21.	68 50.3	4.817
Leitchfield, court-house square.	37 30	86 22	1881	Oct. 7, 8.	68 38.2	4.892

*intensities in the United States and adjacent regions.—Continued.*

IOWA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 89	72. 2	----	----	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14. 02	72. 7	----	----	Do.	Do.
13. 78	72. 2	----	----	Do.	Do.
----		----	----	Do.	{ Sill, J., 1840.
13. 92	72. 4	----	----	Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 85	72. 6	----	----	Do.	Do.
13. 83	72. 7	----	----	Do.	Do.
13. 74	72. 7	----	----	Do.	Do.
13. 77	72. 97	3. 97	13. 56	Do.	Sill, J., 1840, E. Loomis; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----				T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 69				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 82	73. 0	----	----	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 74	73. 0	----	----	Do.	Do.
13. 85	72. 87	4. 05	13. 75	A. Braid.	C. & G. S. Rpt., 1881, App. 9.

## KANSAS.

----	67. 12	5. 08	13. 07	F. E. Nipher.	St. Louis Acad. Sc.
13. 04	66. 74	5. 13	12. 99	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 11	67. 52	4. 99	13. 05	Do.	Do.
----	67. 37	4. 96	12. 89	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	67. 70	4. 93	12. 99	Do.	Do.
13. 41	68. 60	4. 87	13. 35	A. Braid.	C. & G. S. Rpt., 1881, App. 9.
----	68. 63	4. 77	13. 09	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	69. 3	----	----	J. H. Simpson.	Explor's by Capt. Simpson, U. S. E. Stone's Mag. Var's., New York, 1878.
----	69. 4	----	----	Do.	Do.
----	69. 9	----	----	Do.	Do.
----	----	----	----	Do.	Do.

## KENTUCKY.

13. 15	67. 20	5. 07	13. 08	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 13	67. 46	5. 01	13. 07	Do.	Do.
----	68. 12	4. 94	13. 26	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 49	68. 47	4. 88	13. 30	A. T. Mosman and E. Smith.	C. & G. S. Rpt., 1881, App. 9.
----	67. 77	----	----	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
13. 415	68. 95	----	----	J. H. Lefroy.	Diary Mag. Sur., Canada, Sir J. H. Lefroy, London, 1883.
13. 35	68. 28	4. 92	13. 30	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 34	68. 72	4. 82	13. 28	Do.	Do.
13. 43	68. 52	4. 89	13. 35	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
KENTUCKY—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Stanford, court-house grounds.	37 31	84 44	1881	Oct. 15, 16, 17.	69 43.8	4.625
Lebanon, yard of Norris Hotel.	37 36	85 19	1881	Oct. 11, 12, 13.	69 06.8	4.750
Clay's Ferry.	37 54	84 18	1840	Sept. 3.	69 49.0	4.639
Lexington.	38 06	84 18	1840	Sept. 2.	69 54.5	4.603
Shelbyville, east of Observatory.	38 12.8	85 13.2	1871	Nov. 27; Dec. 2.	69 46.6	4.660
Frankfort.	38 14	84 40	1840	Sept. 4.	69 54.9	4.616
Shippingport.	38 15	85 30	1819	May 20.	70 15	----
Louisville.	38 15	85 46	1839	----	70 08	----
Do.	38 15	85 46	1840	Mar. 11.	69 56 69 54.4	4.654
Louisville, in Jacob's Wood.	38 15	85 46	1849	June 18.	69 55.5	----
Louisville.	38 15.1	85 45.5	1856	Nov. 23.	70 08	----
Grayson, lot east of E. K. R. R. depot.	38 18	82 59	1881	Nov. 5, 6.	70 09.3	4.643
Cynthiana, near Protestant cemetery.	38 26	84 25	1881	Oct. 25, 26.	69 44.0	4.626
Flemingsburg, public school grounds.	38 26	83 46	1881	Oct. 31; Nov. 1.	69 45.2	4.627
Williamstown.	38 36	84 22	1840	Sept. 1.	70 04.1	4.603
Falmouth, Coleman's Farm.	38 40.8	84 17.3	1872	Dec. 30; Jan. 9.	70 16.1	4.580

## LOUISIANA.

Southwest Pass, Mississippi Delta.	28 59	89 23	1840	----	58 42.2	----
Southwest Pass, Mississippi Delta, near Stake Island.	28 59	89 23	1872	Mar. 2.	58 46.5	6.209
Southeast Pass, Mississippi Delta.	29 04.7	89 03.6	1859	Dec. 21.	58 45.3	6.377
Cubitt.	29 09.9	89 14.6	1859	Dec. 16.	58 54.0	6.342
Pass à Loutre.	29 10.9	89 01.4	1859	Dec. 27.	58 47.0	6.355
Osgood Island, southeast by east of Pass à Loutre Light.	29 11.3	89 05.3	1872	Mar. 4, 5.	59 01.2	6.068
Magnolia base, lower station.	29 32.5	89 46.6	1872	Jan. 17.	59 23.5	5.977
Brashear City, old earthworks north of town.	29 41	91 14	1872	Mar. 23.	59 16.3	6.093
Côte Blanche.	29 44.1	91 42.9	1860	Mar. 3, 4.	59 08.8	6.349
Barrel Key.	29 54.3	89 08.0	1857	Apr. 14, 18.	59 48.2	6.282
Avery's Island, six and one-half miles south-west of New Iberia.	29 55	91 45	1872	Mar. 13-19.	59 26.4	6.012
New Orleans Mint.	29 57.7	90 03.4	1834	Aug.	60 15	----
New Orleans.	29 58	90 04	1856	Dec. 18, 24.	59 30	6.350
New Orleans, Basin and Canal streets.	29 57.4	90 04.4	1858	Apr. 7, 10.	59 46.5	6.310
New Orleans, city park.	29 55.6	90 07.8	1872	Feb. 10-15.	59 43.5	5.959
New Orleans, fair grounds station.	29 59.1	90 04.8	1872	Feb. 14.	59 48.6	----
Do.	29 59.1	90 04.8	1880	Mar. 24, 25.	59 48.6	6.155
Baton Rouge, mound south of college.	30 26	91 12	1872	Apr. 1-6.	60 20.0	6.008

*intensities in the United States and adjacent regions.—Continued.*

## KENTUCKY—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
13. 35	69. 61	4. 63	13. 29	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 32	69. 00	4. 75	13. 26	Do.	Do.
13. 45	69. 47	----	----	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 41	69. 56	----	----	Do.	Do.
13. 48	69. 45	4. 67	13. 31	A. T. Mosman and E. Smith.	C. & G. S. Rpt., 1881, App. 9.
13. 45	69. 56	----	----	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	69. 55	----	---	S. H. Long.	Maj. Long's Exp. to Rocky Mts., 2 vols. Phila., 1823.
----	69. 64	4. 66	13. 40	J. Locke.	Sill. J., 1840.
13. 55				Do.	Sill. J., 1840; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 574				J. H. Lefroy.	Diary Mag. Sur., Canada, Sir J. H. Lefroy, London, 1883.
----				K. Friesach.	K. K. Acad. d. Wiss, Vienna, vol. 29, 1858.
13. 68	70. 04	4. 65	13. 62	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 36	69. 61	4. 63	13. 29	Do.	Do.
13. 37	69. 63	4. 63	13. 30	Do.	Do.
13. 50	69. 72	----	----	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 57	69. 95	4. 59	13. 39	E. Goodfellow.	C. & G. S. Rpt., 1881, App. 9.

## LOUISIANA.

----	} 58. 8	6. 154	11. 88 {	J. D. Graham.	Sill. J., Vol. IV, 1847.
12. 00				T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9; also Rpt. 1882, App. 14.
12. 29	58. 8	6. 28	12. 12	F. H. Gerdes and J. G. Oltmanns.	C. & G. S. Rpt., 1881, App. 9.
12. 28	59. 0	6. 24	12. 12	Do.	Do.
12. 26	} 58. 9	6. 07	11. 75 {	Do.	Do.
----				T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
11. 74	59. 4	5. 924	11. 64	Do.	C. & G. S. Rpt., 1881, App. 9.
----	59. 3	6. 040	11. 83	Do.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
12. 38	59. 1	6. 25	12. 17	F. H. Gerdes and J. G. Oltmanns.	C. & G. S. Rpt., 1881, App. 9.
12. 49	59. 8	6. 17	12. 27	S. Harris.	Do.
----	59. 5	5. 959	11. 74	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	} 59. 8	6. 021	11. 97 {	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
12. 512				K. Friesach.	K. K. Acad. d. Wiss., Vienna, vol. 29, 1858. H & F were converted into Eng. units.
12. 54				G. W. Dean.	C. & G. S. Rpt., 1881, App. 9.
11. 84				T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9; also Rpt. 1882, App. 14.
----	} 60. 4	5. 955	12. 06 {	Do.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
12. 24				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9; also Rpt. 1882, App. 14.
----				T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

LOUISIANA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Alexandria, Irwin's pasture.	31 17	92 27	1872	Apr. 18.	60 53.0	5.965
Gaines Ferry.	31 28	93 45	1840	May.	60 57.0	----
Natchitoches.	31 44	93 05	1834	Apr.	62 11	----
Do.	31 44	93 07	1840	June.	61 15.9	----
Grand Ecore, breastwork in front of hotel.	31 48	93 07	1872	Apr. 10.	61 27.2	5.901
Sabine River.	32 01	94 00	1840	----	61 36.8	----
Monroe.	32 29	92 08	1872	Apr. 26.	----	5.778
Shreveport, river front, Jones' Hill.	32 30	93 45	1872	Apr. 14.	62 04.4	5.809

## MAINE.

Kittery Point, opposite Portsmouth, N. H.	43 04.8	70 43.0	1850	Aug. 29; Sept. 4.	74 57.2	3.500
Kittery Point.	43 04.8	70 43.0	1859	July 14.	75 04.2	3.496
Do.	43 04.8	70 43.0	1879	Aug. 13, 14.	74 26.2	3.588
Cape Neddick.	43 11.6	70 36.4	1851	Aug. 28, 29, 30.	74 57.9	3.516
Agamenticus.	43 13.4	70 41.5	1847	Sept., Oct., Nov.	74 54.7	3.456
Kennebunkport.	43 21.4	70 28.1	1851	Aug. 23, 27.	75 14.1	3.448
Fletcher's Neck.	43 26.8	70 20.5	1850	Sept. 9, 12.	75 18.3	3.440
Richmond Island.	43 32.6	70 14.4	1850	Sept. 14, 16.	75 08.0	3.464
Portland.	43 41	70 20	1845	June 2.	75 13.7	3.427
Portland, Bramhall or Bowdoin Hill.	43 38.8	70 16.6	1851	Aug. 15, 20.	75 14.1	3.450
Do.	43 38.8	70 16.6	1859	July 15.	74 56.7	3.456
Portland, Munjoy's Hill.	43 39.9	70 14.9	1863	July 6.	75 04.6	3.425
Portland, Bramhall Hill.	43 38.8	70 16.6	1863	July 15.	75 05.9	3.439
Do.	43 38.8	70 16.6	1864	Aug. to Dec.	75 09.5	3.456
Do.	43 38.8	70 16.6	1865	Jan. to Dec.	75 08.3	3.459
Do.	43 38.8	70 16.6	1866	Jan. to Mar.	75 07.4	3.458
Portland, Munjoy's Hill.	43 39.9	70 14.9	1873	Sept. 8, 11.	74 57.9	3.472
Harpwell.	43 44.5	70 00.8	1863	July 22.	75 52.4	3.184
Mount Independence.	43 45.5	70 19.2	1849	Oct. 9-16.	75 23.8	3.422
Cape Small.	43 46.7	69 50.7	1851	Oct. 16-25.	75 01.8	3.389
Freeport.	43 51.1	70 05.9	1863	July 13.	75 20.3	3.395
Brunswick.	43 54.5	69 57.7	1873	Sept. 13-17.	75 08.3	3.437
Bath.	43 54.9	69 49.0	1863	July 11.	75 25.5	3.355
Mount Pleasant.	44 01.6	70 49.3	1851	Aug. 6-27.	76 01.5	3.212
Rockland.	44 06.3	69 06.2	1863	July 7.	75 30.9	3.318
Mount Sebattis.	44 09.1	70 04.8	1853	July 25-29.	75 40.6	3.411
Camden Village.	44 12	69 05	1854	Oct. 26-Nov. 4.	75 41.5	3.345
Mount Ragged.	44 12.8	69 09.1	1854	Sept. 22-26.	75 41.2	3.345
Southwest Harbor, Mount Desert Island.	44 15.0	68 17.6	1856	Sept. 25-30.	76 15.5	3.280
Mount Desert.	44 21.1	68 13.6	1856	Oct. 7-13.	76 09.2	3.255

*intensities in the United States and adjacent regions.—Continued.*

## LOUISIANA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885-0}$	$H_{1885-0}$	$F_{1885-0}$		
----	°				
----	60.9	5.912	12.16	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	61.0	----	----	J. D. Graham.	Sill. J., Vol. IV, 1847.
----	61.4	----	----	J. N. Nicollet.	C. S. Rpt. 1864, App. 19.
----				J. D. Graham.	Sill. J., Vol. IV, 1847.
----	61.5	5.848	12.26	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	61.6	----	----	J. D. Graham.	Sill. J., Vol. IV, 1847.
----	----	5.725	----	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	62.1	5.756	12.30	Do.	Do.

## MAINE.

13.48	73.98	3.611	13.09	J. E. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
13.57				C. A. Schott.	Do.
13.37				J. B. Baylor.	Do.
13.55			13.21	J. E. Hilgard.	Do.
13.28	74.03	3.634	12.85	T. J. Lee and R. H. Fauntleroy.	Do.
13.53	74.01	3.540	13.18	J. E. Hilgard.	Do.
13.56	74.30	3.567	13.18	Do.	Do.
13.50	74.38	3.550	13.13	Do.	Do.
13.44	74.21	3.574		J. Locke.	Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852.
13.54	74.15	3.540		J. E. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
13.31				C. A. Schott.	Do.
13.30			12.96	Do.	Do.
13.37				Do.	Do.
13.49				H. W. Richardson.	Do.
13.49				Do.	Do.
13.47				Do.	Do.
13.38				T. C. Hilgard.	Do.
13.04	74.88	3.28	12.6	C. A. Schott.	Do.
13.57	74.48	3.522	13.16	G. Davidson.	Do.
13.12	74.10	3.508	12.80	G. W. Dean and A. D. Bache.	Do.
13.41	74.36	3.495	12.96	C. A. Schott.	Do.
13.40	74.37	3.483	12.93	T. C. Hilgard.	Do.
13.33	74.45	3.455	12.89	C. A. Schott.	Do.
13.30	75.09	3.330	12.94	G. W. Dean.	Do.
13.26	74.53	3.418	12.81	C. A. Schott.	Do.
13.79	74.72	3.543	13.44	J. E. Hilgard and A. D. Bache.	Do.
13.54	74.72	3.481	13.21	G. W. Dean and R. J. Breckinridge.	Do.
13.53				G. W. Dean and S. Harris.	Do.
13.81	75.27	3.413	13.42	S. Harris.	Do.
13.60	75.16	3.388	13.23	G. W. Dean.	Do.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MAINE—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Locke's Mill.	44 24	70 44	1845	June 15.	75 50.7	3.304
Belfast.	44 26.0	69 00.8	1863	July 8.	75 38.1	3.330
Bethel, C. R. Locke's house.	44 27.5	70 51	1845	June 10.	75 51.0	3.308
Waterville.	44 33	69 45	1849	June, July, Aug.	75 59.4	3.243
Howard.	44 37.7	67 23.7	1859	Aug. 3-13.	75 21.6	3.458
Mount Saunders.	44 39.0	68 36.5	1856	July 8-17; Sept. 12, 14.	75 58.6	3.279
Mount Harris.	44 39.9	69 08.9	1855	Sept. 3-11.	76 14.1	3.240
Bangor.	44 48	68 47	1841	July.	76 11.6	----
Bangor, Thomas Hill.	44 48.2	68 46.9	1857	Oct. 10-16.	76 14.7	3.231
Do.	44 48.2	68 46.9	1863	July 10.	76 05.3	3.208
Do.	44 48.2	68 46.9	1879	Aug. 21.	75 29.8	3.317
Humpback.	44 51.8	68 06.6	1858	Aug. 24-Sept. 15.	76 12.0	3.220
Eastport, Fort Sullivan.	44 54.4	66 59.2	1860	Jan. to Dec.	75 53.1	3.307
Do.	44 54.4	66 59.2	1861	Jan. to Dec.	75 51.0	3.307
Do.	44 54.4	66 59.2	1862	Jan. to Dec.	75 48.5	3.303
Do.	44 54.4	66 59.2	1863	Jan. to Dec.	75 48.3	3.310
Do.	44 54.4	66 59.2	1864	Jan. to July.	75 45.8	3.313
Do.	44 54.4	66 59.2	1865	July 22-25.	75 44.7	3.317
Eastport.	44 54.3	66 59.3	1873	Aug. 28-Sept. 4.	75 24.3	3.363
Do.	44 54.4	66 59.2	1879	Aug. 27, 28.	75 12.2	3.404
Cooper.	44 59.2	67 28.0	1859	Sept. 10-15.	76 20.3	3.180
Calais.	45 11.0	67 16.8	1857	Sept. 18-23.	76 25.5	3.231
Forks of Kennebec.	45 20	69 58	1844	Aug.	76 23.7	----
Moose River.	45 39	70 16	1844	Aug.	76 48.5	----
Tachereau's.	45 49	70 24	1844	----	76 50.4	----
Source of Saint Croix, N. E. boundary station.	45 57.4	67 46.8	1840	Oct.	76 57.4	----
Park's Hill.	46 07	67 47	1840	Nov.	77 02.5	----
Do.	46 07	67 47	1841	Aug.	77 00.7	----
Branch of the Saint John.	46 25	70 04	1844	----	77 24.8	----
River Saint John, near the Grand Forks.	46 35	69 53	1843	----	77 25.9	----
Blue Hill.	46 38	67 47	1841	----	77 18.1	----
Aroostook.	46 47	67 47	1841	----	77 24.1	----
Big Black River, mouth of Chim-passa-ooe-tuc.	46 57	69 27	1843	----	77 37.5	----
Peconk Hill.	46 59	67 47	1841	----	77 32.2	----
Falls of Saint John.	47 03	67 45	1843	----	77 29.5	----
River Saint John, north bank.	47 04	67 47	1843	----	77 31.0	----

*intensities in the United States and adjacent regions.—Continued.*

MAINE—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885-0}$	$H_{1885-0}$	$F_{1885-0}$		
13.52	74.97	3.370	13.00	J. Locke.	Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852.
13.42	74.66	3.430	12.97	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13.54	74.97	3.374	13.01	J. Locke.	Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852.
13.40	75.08	3.341	12.98	G. W. Keely.	C. & G. S. Rpt., 1881, App. 9.
13.68	74.36	3.580	13.28	G. W. Dean and A. D. Bache.	Do.
13.53	75.00	3.412	13.18	G. W. Dean and J. H. Toomer.	Do.
13.62	75.25	3.376	13.26	G. W. Dean and T. M. Melver.	Do.
-----	75.07	3.335	12.95	J. D. Graham.	Sill. J., Vol. IV, 1847.
13.59				G. W. Dean, S. Harris, and H. W. Bache.	C. & G. S. Rpt., 1881, App. 9.
13.34				C. A. Schott.	Do.
13.24				J. B. Baylor.	Do.
13.50	75.21	3.346	13.11	G. W. Dean, A. T. Mosman, and A. D. Bache.	Do.
13.56	74.73	3.413	12.96	G. B. Vose.	Do.
13.53				G. B. Vose and S. Walker.	Do.
13.47				S. Walker, R. H. Talcott, and E. Goodfellow.	Do.
13.30				E. Goodfellow.	Do.
13.48	76.10	-----	-----	E. Goodfellow, A. T. Mosman, and H. W. Richardson.	Do.
13.47				H. W. Richardson.	Do.
13.35				T. C. Hilgard.	Do.
13.33				J. B. Baylor.	Do.
13.46	75.34	3.302	13.05	G. W. Dean and A. D. Bache.	Do.
13.76	75.43	3.361	13.36	G. W. Dean and S. Harris.	Do.
-----	75.53	-----	-----	J. D. Graham.	Sill. J., Vol. IV, 1847.
-----	75.94	-----	-----	Do.	Do.
-----	75.97	-----	-----	Do.	Do.
-----	76.10	-----	-----	Do.	Sill. J., Vol. IV, 1847; Am. Phil. Soc., Vol. IX, 1846.
-----	76.16	-----	-----	Do.	Sill. J., Vol. IV, 1847.
-----				Do.	Phil. Trans. R. S., 1846.
-----	76.54	-----	-----	Do.	Sill. J., Vol. IV, 1847.
-----	76.56	-----	-----	Do.	Do.
-----	76.44	-----	-----	Do.	Do.
-----	76.54	-----	-----	Do.	Do.
-----	76.75	-----	-----	Do.	Do.
-----	76.65	-----	-----	Do.	Do.
-----				Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MAINE—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Little Black River, mouth of Passa-ooe-tuc.	47 07	69 05	1844	----	77 40.5	----
Saint Francis River.	47 11	68 54	1843	----	77 43.5	----
Grand River, mouth.	47 11	67 57	1844	----	77 38.4	----
Do.	47 11	67 57	1847	----	77 36	----
Fort Kent, Fish River.	47 15	68 35	1843	----	77 43.1	----
Albert's Inn, River Saint John.	47 17	68 27	1843	----	77 44.5	----
Beau Lac, head.	47 22	69 03	1843	----	77 47	----
Madawaska River, mouth.	47 22	68 19	1843	----	77 47.5	----
Do.	47 22	68 19	1847	----	77 45	----
Lake Pohenagamook, outlet.	47 28	69 13	1843	----	77 49.2	----

## MARYLAND.

Mason's Landing.	38 13.8	75 15.0	1856	Aug. 30.	70 44.8	4.406
Davis.	38 20.4	75 06.4	1853	Sept. 21-25.	70 57.7	4.332
Calvert.	38 21.5	76 23.6	1871	July 31; Aug. 4.	70 33.9	4.485
Oxford.	38 41.4	76 10.5	1856	Aug. 23.	70 58.0	4.384
Marriott.	38 52.4	76 36.6	1846	May 27; June 2, 4.	71 10.9	4.260
Do.	38 52.4	76 36.6	1849	June 1-16.	71 12.9	4.332
Hill.	38 53.9	76 52.8	1850	Sept. 18-27.	71 12.2	4.317
Do.	38 53.9	76 52.8	1868	Oct. 27, 28, 29.	71 17.1	4.378
South base, Kent Island.	38 53.9	76 22.0	1845	June 3, 4.	71 37.0	4.206
Taylor.	38 59.8	76 28.0	1845	May 31; June 1.	71 40.2	4.231
Do.	38 59.8	76 28.0	1847	May 28; June 1, 5.	71 19.3	4.222
Kent Island, station 1.	39 01.8	76 19.1	1849	June 27-July 9.	71 16.6	4.307
Soper.	39 05.2	76 57.0	1850	July 22-25.	71 56.5	4.144
Webb.	39 05.3	76 40.5	1850	Nov. 20-27.	71 24.0	4.280
Do.	39 05.3	76 40.5	1868	Sept. 23-28.	71 18.5	4.337
Stabler.	39 07.2	76 59.1	1869	Aug. 24-28.	71 28.1	4.287
Bodkin Light.	39 08.0	76 25.5	1847	Apr. 25, 26.	71 43.1	4.189
North Point.	39 11.7	76 26.7	1846	July 7, 8.	71 29.5	4.183
Pool's Island.	39 17.1	76 15.8	1847	June 23; July 1.	71 52.1	4.117
Baltimore, near Washington Monument.	39 17.8	76 36.9	1832	July.	----	4.228
Baltimore, Saint Mary's College.	39 17.5	76 37.5	1834	July.	70 58.6(?)	----
Baltimore, grove in Howard's Wood.	39 18	76 36.6	1839	Sept.	71 50.3	----
Do.	39 17.8	76 36.6	1840	Aug.	71 34.1	4.265
Baltimore, Saint Mary's College and near Washington Monument.	{ 39 17.5 39 17.8	{ 76 37.5 76 36.9	{ 1841	{ Apr. 28.	{ 71 34.1 71 39.2	{ 4.266 4.243
Baltimore, northeast of Washington Monument and at Saint Mary's College.	39 17.8	76 37	1841	Apr. to Sept.	71 43.4	----

*intensities in the United States and adjacent regions.—Continued.*

## MAINE—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	H <sub>1885.0</sub>	F <sub>1885.0</sub>		
----	°				
----	76.81	----	----	J. D. Graham.	Sill. J., Vol. IV., 1847.
----	76.85	----	----	Do.	Do.
----	} 76.74	----	----	Do.	Do.
----		----	----	G. W. Keely.	Phil. Trans. R. S., 1872.
----	76.85	----	----	J. D. Graham.	Sill. J., Vol. IV, 1847.
----	76.87	----	----	Do.	Do.
----	76.91	----	----	Do.	Do.
----	} 76.89	----	----	Do.	Do.
----		----	----	G. W. Keely.	Phil. Trans. R. S., 1872.
----	76.95	----	----	J. D. Graham.	Sill. J., Vol. IV, 1847.

## MARYLAND.

13.36	70.15	4.491	13.23	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13.28	70.39	4.415	13.16	J. E. Hilgard.	Do.
13.48	70.05	4.539	13.30	A. T. Mosman.	Do.
13.44	70.37	4.494	13.38	C. A. Schott.	Do.
13.21	} 70.68	4.366	13.20	T. J. Lee.	Do.
13.45				A. D. Bache and J. Hewston.	Do.
13.40	} 70.69	4.418	13.36	G. W. Dean and A. D. Bache.	Do.
13.64				C. O. Boutelle.	Do.
13.34	71.11	4.268	13.18	T. J. Lee.	Do.
13.45	} 70.97	4.292	13.16	Do.	Do.
13.18				Do.	Do.
13.42	70.75	4.381	13.29	J. Hewston.	Do.
13.37	71.40	4.221	13.23	G. W. Dean and A. D. Bache.	Do.
13.42	} 70.81	4.379	13.32	Do.	Do.
13.53				C. O. Boutelle.	Do.
13.49	70.93	4.348	13.31	Do.	Do.
13.35	} 71.10	4.252	13.13	T. J. Lee.	Do.
13.18				Do.	Do.
13.23	71.36	4.185	13.09	Do.	Do.
----				J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
----				E. H. Courtenay and A. D. Bache.	Am. Phil. Soc., Vol V, 1835; Sill. J., Vol. XXXIV, 1838, E. Loomis. Supposed misprint for 71° 58' 6".
----				E. Loomis.	Sill. J., Vol. XXXIX, 1840.
13.49				A. D. Bache.	C. S. Rpt., 1862; Trans. R. S., 1846.
13.49	} 13.48			J. Locke.	{ Sill. J., Vol. IV., 1847; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13.48				J. D. Graham.	
----					Phil. Trans. R. S., 1846. $\theta$ mean of five determinations.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MARYLAND—Continued.

Name of station.	Latitude <i>φ</i> .	West longi- tude <i>λ</i> .	Year.	Month.	Dip <i>θ</i> .	Horizontal force <i>H</i> .
Baltimore, northeast of Washington Monu- ment and at Saint Mary's College.	39 17.8	76 37	1841	Apr. to Nov.	71 41.5	----
Baltimore, northeast of Washington Monu- ment, in grove.	39 18	76 36.6	1842	---	71 39.7	----
Baltimore, Howard's Wood and garden of Saint Mary's College.	39 17.8	76 37	1842	Oct. 8.	71 43.3	4.234
Do.	39 17.8	76 37	1844	July.	71 36.0	----
Baltimore, Fort McHenry.	39 15.9	76 34.9	1856	Sept. 13.	71 45.8	4.203
Do.	39 15.9	76 34.9	1877	Oct. 13.	71 36.5	4.246
Rosanne.	39 17.5	76 43.1	1845	June 10, 11.	72 06.6	4.053
Maryland Heights.	39 20.4	77 43.0	1870	Oct. 17–Nov. 6.	71 28.0	4.324
Finlay.	39 24.4	76 31.5	1845	June 13, 14.	71 52.9	4.059
Do.	39 24.4	76 31.5	1846	Apr. 10–16.	71 47.9	4.113
Osborne's Ruin.	39 27.9	76 16.9	1845	June 25, 30; July 2, 3.	71 47.6	4.143
Susquehanna Light.	39 32.4	76 05.1	1847	July 6, 7, 8.	71 52.1	4.086
Frenchtown.	39 35	75 51	1840	Aug.	71 40.2	4.312
Cumberland.	39 39	78 44	1844	Mar. 26.	71 36.0	4.265
Frostburgh.	39 41	78 56	1840	Aug.	71 31.3	4.298
Emmitsburgh, Mount Saint Mary's College.	39 41	77 18	1842	Apr. 12.	71 46.3	4.244

## MASSACHUSETTS.

Nantucket.	41 17.0	70 06.0	1843	Sept.	73 41.2	----
Nantucket, on North Beach.	41 17.5	70 06.0	1846	July 29; Aug. 2.	73 44.4	3.653
Nantucket, on beach west of light-house.	41 17.5	70 06.0	1855	Aug. 22.	74 00.6	3.626
Nantucket, cliff station.	41 17.2	70 06.3	1867	May 28; June 5.	73 37.6	3.749
Nantucket, bluff.	41 17.3	70 06.3	1875	Sept. 15–17.	73 24.1	3.817
Nantucket, cliff.	41 17.2	70 06.3	1879	July 31; Aug. 2.	73 15.1	3.799
Sampson's Hill.	41 22.7	70 29.0	1846	July 22; Aug. 15.	73 24.5	3.753
Indian, near station.	41 25.7	70 40.6	1845	July 30; Aug. 4, 5	73 41.4	3.734
Indian.	41 25.7	70 40.7	1846	Aug. 11, 12, 13.	73 29.1	3.728
Vineyard Haven.	41 27.9	70 35.5	1875	Sept. 21, 22.	73 09.9	3.893
Tarpaulin Cove.	41 28.1	70 45.4	1846	Aug. 7, 8.	73 49.8	3.696
Fairhaven.	41 37.4	70 54.1	1845	Oct. 16, 17.	74 40.0	3.592
Hyannis.	41 37.9	70 18.4	1846	Aug. 22–25.	73 49.2	3.682
Chatham.	41 40.2	69 56.9	1860	Sept. 10, 11.	73 46.2	3.744
Shootflying.	41 41.1	70 20.8	1845	Aug. 25; Sept. 2.	74 23.3	3.657
Do.	41 41.1	70 20.8	1846	Aug. 28, 29, 30.	73 56.5	3.663
Copcut.	41 43.3	71 03.6	1844	Oct. 3, 4.	74 09.5	----
Manomet.	41 55.6	70 35.5	1845	Sept. 12.	74 30.0	3.640
Do.	41 55.6	70 35.5	1846	Sept. 1.	74 01.2	----
Do.	41 55.6	70 35.5	1867	Aug. 7–22.	73 58.5	3.760

*intensities in the United States and adjacent regions.—Continued.*

## MARYLAND—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	o				
----	71. 16	4. 291	13. 29	J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, 1843. $\theta$ mean of four determinations.
----				J. D. Graham.	Phil. Trans. R. S., 1846.
13. 499				J. H. Lefroy.	Diary Mag. Sur. Canada, Gen'l Sir J. H. Lefroy, London, 1883.
----				J. D. Graham.	Phil. Trans. R. S., 1846. $\theta$ mean of two determinations.
13. 43				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 46				J. B. Baylor.	Do.
13. 19	71. 60	4. 115	13. 04	T. J. Lee.	Do.
13. 60	70. 94	4. 382	13. 42	C. O. Boutelle.	Do.
13. 05	71. 33	4. 150	12. 96	T. J. Lee.	Do.
13. 17				T. J. Lee and J. Locke.	Do.
13. 26	71. 28	4. 205	13. 10	T. J. Lee.	Do.
13. 13	71. 36	4. 154	13. 00	Do.	Do.
----	71. 15	4. 354	13. 48	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 51	71. 09	4. 323	13. 34	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	71. 00	4. 340	13. 33	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 57	71. 26	4. 294	13. 37	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.

## MASSACHUSETTS.

----				W. Mitchell.	Sill. J., Vol. XLVI.
13. 04	72. 81	3. 815	12. 91	T. J. Lee.	C. & G. S. Rpt., 1881, App. 9.
13. 16				C. A. Schott.	Do.
13. 30				C. O. Boutelle.	Do.
13. 36				J. M. Poole.	Do.
13. 18				J. B. Baylor.	Do.
13. 14	72. 53	3. 827	12. 75	T. J. Lee.	Do.
13. 29	72. 71	3. 801	12. 79	Do.	Do.
13. 12				Do.	Do.
13. 44	72. 47	3. 928	13. 04	J. M. Poole.	Do.
13. 27	72. 94	3. 770	12. 85	T. J. Lee.	Do.
13. 58	73. 79	3. 660	13. 11	Do.	Do.
13. 21	72. 93	3. 756	12. 80	T. J. Lee and R. H. Fauntleroy.	Do.
13. 39	72. 77	3. 861	13. 04	C. A. Schott.	Do.
13. 59	73. 28	3. 730	12. 97	T. J. Lee.	Do.
13. 24				T. J. Lee and R. H. Fauntleroy.	Do.
----	73. 29	----	----	T. J. Lee.	Do.
13. 62	73. 26	3. 772	13. 10	Do.	Do.
----				R. H. Fauntleroy.	Do.
13. 62				C. O. Boutelle.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MASSACHUSETTS—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Wellfleet.	41 56.1	70 01.8	1860	Sept. 12, 13.	74 20.2	3.638
Plymouth.	41 58	70 39	1876	July 11, 12.	73 48.3	3.745
Longmeadow, west of village church.	42 02	72 36	1839	Sept.	74 05.3	----
Provincetown.	42 03.2	70 11.1	1860	Sept. 14, 15.	74 09.7	3.656
Springfield.	42 06	72 36	1834	Aug.	74 11	----
Do.	42 06	72 36	1834	Aug.	74 10.7	----
Springfield, rear of Pinchyn House.	42 06	72 36	1835	----	----	3.721
Springfield, east of Hampton coffee-house.	42 06	72 36	1839	Sept.	74 06.9	----
Springfield.	42 06	72 36	1841	----	74 10.7	----
Springfield, in yard west of American Hotel.	42 01	72 36	1843	March 25.	73 39.7	----
Springfield, near Chestnut and East Worthing- ton streets.	42 06	72 32	1859	July 26.	74 14.9	3.691
Blue Hill.	42 12.7	71 06.9	1845	Sept. 29—Oct. 8.	75 05.6	3.519
Easthampton.	42 15	72 40	1862	July 7—11.	74 06.1	3.691
Worcester, west of Worcester House.	42 16	71 48	1839	Sept.	74 20.6	----
Nantasket.	42 18.2	70 54.3	1847	Sept. 1, 2, 3.	74 15.9	3.566
Dorchester, South Boston Heights.	42 19	71 04	1839	----	74 19	----
Do.	42 19	71 04	1839	Sept.	74 16.0	3.658
Boston.	42 21	71 04	1841	July.	74 09.4	----
Do.	42 20	71 04	1842	May 2.	74 05.7	3.669
Dorchester, South Boston, near Grove Hill.	42 19	71 03	1842	Oct. 1.	74 12.8	----
Dorchester, South Boston Heights.	42 20	71 02.6	1846	Sept. 3—7.	74 12.7	3.587
Dorchester, South Boston Heights, near Blind Asylum.	42 20	71 02.6	1855	Aug. 24.	74 29.5	3.544
Do.	42 20	71 02.4	1872	Sept., Oct.	73 31 (?)	3.675
Cambridge.	42 23	71 07	1780	Dec. 25.	69 51	----
Do.	42 23	71 07	1782	June 2.	69 41	----
Do.	42 23	71 07	1783	Dec. 23.	69 41	----
Cambridge, southwest of colleges.	42 22.5	71 07.5	1839	Sept.	74 20.1	----
Cambridge, Harvard College Observatory.	42 23	71 08	1840	----	74 21.6	----
Do.	42 22.9	71 07.7	1841	June.	74 17.3	----
Cambridge, grounds of Observatory.	42 22.9	71 07.7	1842	----	74 19.5	3.665
Cambridge.	42 23	71 08	1842	----	74 17.8	----
Do.	42 23	71 08	1842	May 4.	74 14.9	3.661
Cambridge, new Observatory.	42 22.9	71 07.7	1844	Dec.	74 18.2	----
Cambridge, Observatory grounds.	42 23	71 08	1845	June 2.	74 19.4	3.618
Cambridge, Harvard College Observatory.	42 22.9	71 07.7	1850	Aug. 9.	74 34	----

*intensities in the United States and adjacent regions.—Continued.*

## MASSACHUSETTS—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
13. 48	73. 34	3. 755	13. 10	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
----	73. 16	3. 777	13. 04	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected by C. A. S.]
----	73. 23	----	----	E. Loomis.	Sill. J., 1840.
13. 40	73. 16	3. 773	13. 02	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
----	73. 20	3. 772	13. 05	A. D. Bache.	Sill. J., 1838, E. Loomis.
----				Do.	Sill. J., Vol. XXXIV, 1838, E. Loomis.
13. 65				A. D. Bache and E. H. Courtenay.	Am. Phil. Soc., Vol. V, 1837; C. S. Rpt., 1851, App. 22. H. at Phila.=4.195, used as unit (Schott).
----				E. Loomis.	Sill. J., 1840.
----				A. D. Bache.	Phil. Trans. R. S., 1846.
13. 379	73. 21	3. 695	12. 79	J. H. Lefroy.	Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883.
13. 60				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 68				T. J. Lee.	Do.
13. 47				E. Goodfellow and A. D. Bache.	Do.
----				E. Loomis.	Sill. J., 1840.
13. 15	73. 37	3. 648	12. 75	T. J. Lee.	Do.
----	73. 28	3. 704	12. 88	W. C. Bond.	Do.
13. 39				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----				J. D. Graham.	Sill. J., Vol. IV, 1847.
13. 40				J. Locke.	Do.
13. 327				J. H. Lefroy.	Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883.
13. 18	73. 28	3. 704	12. 88	T. J. Lee and R. H. Fauntleroy.	C. & G. S. Rpt., 1881, App. 9.
13. 26				C. A. Schott.	Do.
12. 95 (?)				A. H. Scott and E. Goodfellow.	Do.
----				Williams.	Sill. J., Vol. XXXIV, 1838, E. Loomis.
----				Do.	Do.
----	73. 28	3. 704	12. 88	Do.	Do.
----				E. Loomis.	Sill. J., Vol. XXXIX, 1840.
----				J. Lovering and W. Bond.	Mem. Am. Acad., Vol. II, 1846.
----				J. D. Graham & W. C. Bond.	Phil. Trans. R. S., 1846, Tab. LI, E. Sabine.
13. 458				J. H. Lefroy.	Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883.
----	73. 28	3. 704	12. 88		Phil. Trans. R. S., 1846. $\theta$ , H & F., obs'd.
----				J. D. Graham.	Sill. J., Vol. IV, 1847.
13. 49				J. Locke.	Sill. J., Vol. IV, 1847; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----				J. D. Graham.	Phil. Trans. R. S., 1846, Tab. LI. E. Sabine.
13. 39				J. Locke.	C. S. Rpt., 1861, App. 22.
----				J. C. Ives and A. W. Whipple.	C. S. Rpt., 1856, p. 222.



TABLE I.—*Observed magnetic dips and horizontal and total*  
MASSACHUSETTS—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Cambridge, Harvard College Observatory.	42 22.9	71 07.7	1854	May 10.	74 33	----
Do.	42 23	71 08	1856	July 19.	74 12	3.542
Do.	42 22.9	71 07.7	1859	Mar. 7.	74 20	3.596
Cambridge, grounds of Harvard College Ob- servatory.	42 22.8	71 07.6	1879	Aug. 7-9.	73 48.4	3.707
Chesterfield.	42 24	72 51	1859	July 25.	74 21.2	3.667
Little Nahant.	42 26.2	70 55.8	1849	Aug. 13-17.	74 29.5	3.556
Wachusett.	42 29.2	71 53.2	1860	Sept. 27-Oct. 10.	74 28.8	3.633
Fort Lee, Salem.	42 31.9	70 52.5	1849	Aug. 18.	----	3.487
Do.	42 31.9	70 52.5	1855	Aug. 25.	75 36.9	3.489
Baker's Island Light.	42 32.2	70 47.2	1849	Aug. 31-Sept. 3.	74 18.6	3.682
Deerfield.	42 33	72 36	1859	July 23.	74 35.3	3.617
Fitchburg.	42 35	71 48	1876	July 22.	74 09.8	3.694
Greenfield.	42 35	72 35	1876	July 25, 26.	74 06.1	3.702
Beaconhill, Gloucester.	42 36.2	70 38.6	1849	Aug. 21, 25.	74 26.4	3.617
Do.	42 36.2	70 38.6	1859	July 8.	74 45.6	3.645
Thompson.	42 36.7	70 43.8	1859	July 9.	74 30.4	3.674
Lowell.	42 39	71 20	1876	July 19, 20.	74 19.3	3.635
Annisquam.	42 39.4	70 40.6	1859	July 11.	74 56.1	3.589
Rockport.	42 39.6	70 36.6	1859	July 11.	75 05.9	3.529
Ipswich.	42 40.8	70 50.1	1859	July 12.	74 37.3	3.598
North Adams.	42 42	73 07	1876	July 28, 29.	74 15.3	3.709
Plum Island, near Newburyport.	42 48.0	70 48.8	1850	Sept. 18, 19.	74 54.9	3.530
Do.	42 48.0	70 48.8	1859	July 13.	74 52.9	3.528

## MICHIGAN.

Monroe, southeast of village.	41 55	83 27	1839	May.	73 32.3	----
Monroe, one mile north of court-house.	41 55	83 28	1841	Aug.	73 19.0	----
Ypsilanti, hill east side of Huron River.	42 14	83 37	1839	May.	73 18.0	----
Ypsilanti, east of railroad depot.	42 14	83 38	1841	Aug.	73 18.8	----
Marshall, near astronomical post.	42 16.4	84 57.8	1876	Oct. 16, 17, 18.	73 30.9	3.9233
Ann Arbor, west of village.	42 18	83 44	1839	May.	73 13.9	----
Ann Arbor, south of railroad depot.	42 18	83 45	1841	Aug.	73 16.5	----
Ann Arbor.	42 16.8	83 43.8	1843	Aug. 13, 14.	73 13.7	3.991
Detroit.	42 20	83 02	1839	May.	73 42.6	----
Detroit, one mile west of the city.	42 20	83 02	1841	Aug.	73 35.7	----
Detroit, Judge Farnsworth's orchard, upper end of city.	42 20	83 02	1841	Sept.	73 32.7	----
Detroit, lane from wharf to Jefferson avenue.	42 21	83 02	1842	Nov. 4.	73 28.7	----

*magnetic intensities in the United States and adjacent regions—Continued.*

## MASSACHUSETTS—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$O_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	o			J. C. Ives and A. W. Whipple.	C. S. Rpt., 1856, p. 222.
13. 006				K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. Total force converted into Eng. units.
13. 318				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859.
13. 29				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 60	73. 35	3. 789	13. 22	C. A. Schott.	Do.
13. 30	73. 57	3. 655	12. 92	G. W. Keely.	Do.
13. 58	73. 48	3. 750	13. 19	G. W. Dean, R. E. Halter, and A. D. Bache.	Do.
----				G. W. Keely.	Do.
14. 04	} 74. 63	3. 606	13. 61	C. A. Schott.	Do.
13. 62	73. 39	3. 781	13. 23	G. W. Keely.	Do.
13. 61	73. 59	3. 739	13. 23	C. A. Schott.	Do.
----	73. 52	3. 726	13. 13	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Cor- rected by C. A. S.]
----	73. 46	3. 734	13. 12	Do.	Do.
13. 48				G. W. Keely.	C. & G. S. Rpt., 1881, App. 9.
13. 86	} 73. 64	3. 741	13. 28	C. A. Schott.	Do.
13. 75	73. 51	3. 796	13. 37	Do.	Do.
----	73. 68	3. 667	13. 05	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Cor- rected by C. A. S.]
13. 81	73. 93	3. 711	13. 41	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 72	74. 10	3. 651	13. 33	Do.	Do.
13. 57	73. 62	3. 720	13. 19	Do.	Do.
----	73. 62	3. 741	13. 26	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Cor- rected by C. A. S.]
13. 56				J. E. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
13. 53	} 73. 93	3. 645	13. 17	C. A. Schott.	Do.

## MICHIGAN.

----	} 72. 91	----	----	E. Loomis.	{ Sill. J., 1840. Am. Phil. Soc., Vol. VIII, 1843.
----				Do.	{ Sill. J., 1840. Am. Phil. Soc., Vol. VIII, 1843.
13. 826	73. 13	3. 956	13. 63	C. F. Powell.	U. S. Lake Sur., Rpt. 1877 & 1882.
----				E. Loomis.	Sill. J., 1840.
----	} 72. 73	4. 045	13. 63	Do.	Am. Phil. Soc., Vol. VIII, 1843.
13. 83				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844; Sill. J., Vol. IV, 1847.
----				E. Loomis.	Sill. J., Vol. XXXIX., 1840.
----				Do.	Am. Phil. Soc., Vol. VIII., 1843.
----				J. N. Nicollet.	Do.
13. 820				C. Younghusband.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MICHIGAN—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Detroit.	42 21	83 02	1843	June 12, 15.	73 32. 2	3. 892
Detroit, lane from wharf to Jefferson avenue.	42 21	83 02	1845	---	73 38. 8	----
Detroit, Washington avenue, near Grand River avenue.	42 20. 0	83 02. 5	1859	Apr.	73 41	3. 838
Do.	42 20. 0	83 02. 5	1860	May.	73 43	3. 865
Detroit, in park near lake survey office.	42 20. 0	83 02. 5	1872	May 8-29.	73 35	3. 881
Do.	42 20. 0	83 02. 5	1873	May 5-16.	73 34	3. 880
Do.	42 20. 0	83 03. 1	1876	May, June.	73 34. 1	3. 898
Fort Gratiot, near astronomical station.	42 59. 9	82 25. 0	1858	Oct. 9.	74 28	3. 6890
Fort Gratiot, near geodetic station.	43 01	82 25	1860	May 7.	74 39	3. 664
Fort Gratiot, near old bake-house.	42 59. 9	82 25. 0	1873	July 15, 16.	74 22	3. 716
Grand Haven, near Detroit and Milwaukee freight depot.	43 05. 2	86 12. 6	1859	Aug. 18.	74 10	3. 815
Grand Haven, in rear of jail.	43 05. 0	86 12. 6	1873	Aug. 27, 28, 29.	73 58	3. 850
Grand Haven.	43 04. 7	86 12. 6	1880	July 20, 21.	73 53. 7	3. 847
Wahley, on bluff near shore.	43 22	82 32	1860	May 11.	74 41	3. 670
Saint Louis, near astronomical post.	43 24. 5	84 36. 2	1876	Oct. 14, 15.	73 48. 9	3. 6432
Saginaw, near astronomical post.	43 25. 1	83 57. 8	1876	Sept. 16-22.	73 36. 2	3. 6718
Forestville, near astronomical station.	43 39. 6	82 34. 3	1858	June and July.	75 00	3. 5246
Forestville, near astronomical post.	43 39. 6	82 34. 2	1873	July 11, 12.	74 54	3. 636
Sand Point, Saginaw Bay.	43 54. 7	83 23	1858	Sept. 13-18.	75 02	3. 5718
Sturgeon Point, near astronomical station.	44 42. 6	83 14. 1	1858	Sept. 25-29.	75 59	3. 3388
South Manitou Island, middle of island.	45 02	86 06	1841	Aug.	75 59. 3	----
South Manitou Island, 40 yards from wharf.	45 02	86 06	1842	Nov. 7.	75 56. 6	----
South Manitou Island, east side, near dock.	45 02	86 06	1860	Sept. 11.	76 01	3. 360
Thunder Bay Island, near astronomical station.	45 02. 2	83 09. 1	1858	Aug. 20-25.	76 24	3. 2411
Northport, shore of Grand Traverse Bay.	45 08	85 36	1860	Sept. 2.	76 06	3. 340
Cove Island, near light-house.	45 20	81 43	1860	Aug. 28.	76 32	3. 267
Beaver Island, near light-house.	45 45	85 30	1860	Oct. 2.	76 43	3. 236
Mackinac, $\frac{1}{4}$ mile southwest of fort.	45 51	84 40	1841	Aug.	76 37. 5	----
Michillimackinac Island, $\frac{1}{4}$ mile southwest of new Fort Mackinac.	45 51. 5	84 38	1841	Sept.	76 34. 2	----
Michillimackinac Island, near old Fort Holmes.	45 51. 5	84 37. 0	1841	Sept.	76 34. 9	----
Mackinac Island.	45 51	84 39	1843	June 18.	76 38. 8	3. 257
Mackinac Island, without the fort.	45 51	84 36	1860	July 28.	76 43	3. 242
Mackinac, in rear of fort.	45 51	84 38	1880	July 28, 29.	76 27. 6	3. 264
Fort Brady, southeast of fort.	46 29. 9	84 20	1841	Aug.	77 29. 7	----
Sault de St. Marie.	46 30	84 20	1843	June.	77 30. 2	3. 046
Do.	46 30	84 20	1856	Sept. 29.	77 44	3. 0732
Fort Brady, near Sault de St. Marie.	46 30. 1	84 20	1873	July 22, 23.	77 30	3. 044
Sault de St. Marie and Fort Brady.	46 29. 9	84 20. 1	1880	July 11, 13, 19.	----	3. 000
Sault de St. Marie, garden of Fort Brady.	46 29. 9	84 20. 1	1880	Aug. 6, 7.	77 24. 0	3. 056

*intensities in the United States and adjacent regions.—Continued.*

## MICHIGAN—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 73	°			J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844; Sill. J., Vol. IV, 1847.
13. 72	73. 09	3. 934	13. 53	J. H. Lefroy.	Phil. Trans. R. S., 1846; Diary Mag. Sur. Can., Genl. Sir J. H. Lefroy, London, 1883.
13. 710				W. P. Smith.	U. S. Lake Sur. Rpt., 1859 & 1882.
13. 785				Do.	U. S. Lake Sur. Rpt., 1882.
13. 720				A. N. Lee.	U. S. Lake Sur. MS., 1873, & Rpt., 1882.
13. 715				Do.	Do.
13. 781				T. N. Bailey.	U. S. Lake Sur. Rpt., 1877, pt. 2, & 1882.
13. 798				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
13. 840	73. 94	3. 761	13. 60	Do.	U. S. Lake Sur. Rpt., 1882.
13. 790				A. N. Lee.	U. S. Lake Sur. MS., 1873, & Rpt., 1882.
13. 987				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
13. 940	73. 58	3. 886	13. 75	A. N. Lee.	U. S. Lake Sur. MS., 1873, & Rpt., 1882.
13. 87				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 893	74. 08	3. 754	13. 69	W. P. Smith.	U. S. Lake Sur. Rpt., 1882.
13. 070	(73. 44)	3. 677	(12. 90)	D. W. Lockwood.	U. S. Lake Sur. Rpt., 1877 & 1882.
13. 007	(73. 21)	3. 706	(12. 83)	Do.	Do.
13. 609				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
13. 957	74. 42	3. 646	13. 57	A. N. Lee.	U. S. Lake Sur. MS., 1873, & Rpt., 1882.
13. 835	74. 43	3. 657	13. 62	W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
13. 786	75. 38	3. 424	13. 57	Do.	Do.
----				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
14. 041				C. Younghusband.	Diary Mag. Sur. Canada, Gen'l J. H. Lefroy, London, 1843.
13. 937	75. 43	3. 460	13. 75	W. P. Smith.	U. S. Lake Sur. Rpt., 1882.
13. 792	75. 80	3. 326	13. 56	Do.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
13. 905	75. 50	3. 423	13. 67	Do.	U. S. Lake Sur. Rpt., 1882.
14. 063	75. 93	3. 350	13. 78	Do.	Do.
14. 084	76. 12	3. 319	13. 84	Do.	Do.
----				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----				J. N. Nicollet.	Do.
----				Do.	Do.
14. 10	76. 12	3. 306	13. 78	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14. 108				W. P. Smith.	U. S. Lake Sur. Rpt., 1882.
13. 94				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
14. 08				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14. 366				K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858.
14. 064	77. 05	3. 087	13. 77	A. N. Lee.	U. S. Lake Sur. MS., 1873, and Rpt., 1882.
----				S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
14. 01				J. B. Baylor.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MICHIGAN—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	$^{\circ}$ /	$^{\circ}$ /			$^{\circ}$ /	
Marquette, $\frac{1}{2}$ mile northwest of light-house.	46 32.7	87 23.5	1859	July 13.	77 17	3.089
Marquette, northwest of light-house.	46 32.7	87 23.5	1873	July 26, 28, 29.	75 48	3.433
Encampment, shore of Lake Superior.	46 44	87 43	1843	July 2.	76 58.3	3.166
Ontonagon.	46 52	89 21	1843	July 26.	77 13.2	3.122
Ontonagon, near light-house.	46 52.2	89 20	1859	July 19.	77 27	3.064
Ontonagon.	46 52.2	89 20	1880	Aug. 16, 17.	77 16.6	3.094
Eagle River.	47 27	88 23	1843	July 13.	77 54.5	2.949
Copper Harbor, near Eagle Harbor, Fort Wilkins.	47 28.5	87 51.0	1859	July 14.	78 06	2.894
Do.	47 28.5	87 51.0	1873	Aug. 1, 2, 3.	78 02	2.928
Houghton's River.	47 28	88 01	1843	July 8.	77 20.7	3.054
Magnetic Inlet.	47 28.5	88 01	1843	July 8, 11.	78 44.3	2.821
United States Agency.	47 28	88 00	1843	July 8.	77 13.5	3.263
Isthmus.	47 28.5	88 00	1843	July 11.	78 28	2.866
East of Magnetic Inlet, 500 feet.	47 28.5	88 01	1843	July 15.	78 37.5	2.837
Isle Royal.	48 06	88 47	1843	July 28.	78 07.6	2.941

## MINNESOTA.

Heron Lake.	43 47.6	95 24	1880	Oct. 4, 5.	73 31.2	3.924
Wabasha, near Riverside house.	44 18.0	92 07.0	1876	Aug. 7, 8, 11, 12.	74 21.6	3.724
Red Wing, near astronomical post.	44 33.7	92 32.0	1878	Oct. 23-26.	74 14.4	3.680
Saint Peter, Fort Snelling.	44 52	93 10	1836	July.	74 00	3.806
Fort Snelling Reservation.	44 53.5	93 11	1880	Sept. 28, 29.	74 55.6	3.619
Saint Paul, near county court-house.	44 56.7	93 05.4	1873	Aug. 18, 19, 20.	74 55	3.648
Minneapolis.	44 58.6	93 14.1	1877	Sept. 28; Oct. 2.	74 45.2	3.662
Brainerd.	46 21.0	94 15	1880	Aug. 31; Sept. 1.	75 42.5	3.422
Minnesota Point, near south base.	46 42.8	92 01.7	1871	June 23.	76 26	3.266
Minnesota Point, near north base.	46 45.4	92 04.5	1871	June 16-25.	76 21	3.319
Duluth, southeast of Peck's house.	46 45.5	92 04.5	1873	Aug. 12, 13, 14.	76 17	3.395
Minnesota Point, near light-house.	46 46.5	92 05	1859	July 22.	76 44	3.222
Glyndon.	46 52.4	96 40	1880	Sept. 4, 6.	75 48.2	3.415

## MISSISSIPPI.

East Pascagoula.	30 20.7	88 32.8	1847	June 22, 23.	----	6.220
Do.	30 20.7	88 32.8	1848	June 1, 4.	60 27.2	----
Do.	30 20.7	88 32.9	1855	Jan. 24; Feb. 3.	----	6.250

*intensities in the United States and adjacent regions.—Continued.*

## MICHIGAN—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
14. 034 13. 991	76. 00	3. 326	13. 75	W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
14. 05				A. N. Lee.	U. S. Lake Sur. MS., 1873, and Rpt., 1882.
14. 11	76. 46	3. 220	13. 75	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14. 100				Do.	Do.
14. 05				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
14. 08				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
14. 033	77. 39	3. 003	13. 76	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14. 116				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882.
13. 94				A. N. Lee.	U. S. Lake Sur. MS., 1873, & Rpt., 1882.
14. 45				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14. 76	77. 58	3. 020	14. 04	Do.	Do.
14. 33				Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. Dip disturbed.
14. 39				Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14. 29				Do.	Do.
	77. 62	2. 995	13. 97	Do.	Do.

## MINNESOTA.

13. 83	73. 45	3. 93	13. 80	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 814	74. 2	3. 73	13. 70	T. N. Bailey.	U. S. Lake Sur. Rpt. Chief of Eng's, 1877, & Lake Sur. Rpt., 1882.
13. 547	74. 1	3. 69	13. 47	C. F. Powell.	U. S. Lake Sur. Rpt., 1879 & 1882.
----	74. 8	3. 62	13. 81	J. N. Niccollet.	C. S. Rpt., 1864, App. 19. This station now called Mendota.
13. 92				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
14. 018	74. 8	3. 65	13. 92	A. N. Lee.	U. S. Lake Sur. MS., 1873, & Rpt., 1882.
13. 92	74. 6	3. 67	13. 82	A. Braid.	C. & G. S. Rpt., 1881, App. 9.
13. 86	75. 64	3. 43	13. 84	J. B. Baylor.	Do.
13. 925	76. 16	3. 32	13. 88	C. B. Comstock.	U. S. Lake Sur. MS., 1875, & Lake Sur. Rpt., 1882.
14. 065				Do.	Do.
14. 318				A. N. Lee.	U. S. Lake Sur. MS., 1873, & Lake Sur. Rpt., 1882.
14. 038				W. P. Smith.	U. S. Lake Sur., G. G. Meade, Detroit, 1859, & Lake Sur. Rpt., 1882.
13. 92	75. 73	3. 42	13. 88	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.

## MISSISSIPPI.

12. 61	60. 4	6. 25	12. 65	R. H. Fauntleroy and J. S. Ruth.	C. & G. S. Rpt., 1881, App. 9.
----				G. Davidson.	Do.
----				J. E. Hilgard.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MISSISSIPPI—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Mississippi City.	30 22.9	89 02.0	1855	Mar. 27, 28.	----	6.195
Natchez, Chotard's residence.	31 33.8	91 24.7	1834	Mar., May.	62 11	6.149
Natchez, bluff north end of town.	31 34	91 24	1872	Apr. 22.	61 26.7	5.874
Jackson, rear of Free School.	32 19	90 12	1872	Apr. 28.	----	5.665
Vicksburg, Castle Hill, east of school-house.	32 21	90 53	1872	Apr. 24.	62 28.4	5.749
Grenada, northwest of town.	33 47	89 50	1872	Mar. 20.	64 24.0	5.510
Oxford, south of University grounds.	34 22	89 32	1871 1872	Dec. 24. May 3-9.	65 04.4	5.426
Do.	34 22	89 32	1872	May 15.	65 05.3	5.408
Oxford University grounds.	34 22	89 32	1879	Dec. 1.	55 08.8	----
Corinth, between old forts.	34 56	88 35	1871	Dec. 3.	65 54.6	5.248

## MISSOURI.

Gatewood.	36 31.8	91 03.0	1880	July 13.	----	5.022
Doniphan.	36 37.8	90 46.8	1880	July 12.	----	5.011
Poplar Bluffs.	36 44.4	90 21.6	1880	July 10.	67 14.0	5.026
Charleston.	36 55.8	89 19.2	1880	July 8.	67 47.0	4.948
Howell Co.	36 56.0	91 55.2	1880	Aug. 3.	67 37.1	4.940
Piedmont.	37 08.4	90 41.4	1880	July 16.	67 35.4	5.004
Springfield.	37 15.6	93 14.6	1879	Aug. 29.	67 12.6	5.115
Houston.	37 19.2	91 55.2	1880	Aug. 1.	67 16.4	5.030
Lutesville.	37 20.0	89 58.8	1880	July 6.	67 51.7	4.959
Bolivar.	37 35	93 24	1881	Aug. 2.	67 49.2	4.989
Pilot Knob, base.	37 37	90 37	1880	July 19.	69 59.2	4.590
Pilot Knob, top.	37 37	90 37	1880	July 20.	----	4.608
Buffalo.	37 37	93 06	1881	Aug. 1.	67 57.0	4.953
Salem.	37 39.0	91 30.6	1880	July 29.	68 01.8	4.952
Lebanon.	37 40.0	92 42.0	1879	Aug. 30, 31.	67 57.6	4.981
Do.	37 40.0	92 42.0	1881	July 30.	----	4.968
Arcadia.	37 46.2	90 40.8	1880	July 17.	68 33.9	4.889
Wheatland.	37 56	93 24	1881	Aug. 5.	68 16.6	4.855
Schell City.	38 02.6	94 04.6	1879	Aug. 25.	68 20.2	4.898
Cuba.	38 03.6	91 21.0	1880	July 28.	68 18.8	4.887
Linn Creek.	38 04	92 47	1881	July 27.	68 14.5	4.904
De Soto.	38 06.6	90 34.8	1880	July 21.	68 45.4	4.789
Lawson's farm.	38 11	92 11	1881	July 20.	68 20.6	4.927
Vienna.	38 12	91 54	1881	July 18.	68 39.6	4.793
Tuscumbia.	38 12	92 30	1881	July 22.	68 08.5	4.897
Canaan.	38 19	91 32	1881	July 16.	68 47.3	4.800
Lincoln.	38 23	93 21	1881	Aug. 8.	68 22.6	4.871
Roedersville.	38 24	91 10	1881	July 9, 10.	69 00.5	4.798

*intensities in the United States and adjacent regions.—Continued.*

## MISSISSIPPI—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°				
----	----	6.20	----	J. E. Hilgard and J. S. Harris.	C. & G. S. Rpt., 1881, App. 9.
----	} 61.7	5.87	12.38	J. N. Nicollet.	C. S. Rpt., 1864, App. 19. Dip obs'd in Mar., horiz. intensity in May.
----				T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser.
----	----	5.66	----	Do.	Do.
----	62.4	5.75	12.41	Do.	Do.
----	64.3	5.51	12.71	Do.	Do.
----	} 65.1	5.41	12.85	Do.	Do.
----				Do.	Do.
----				B. B. Jenkins.	MS. communication.
----	65.8	5.25	12.81	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser.

## MISSOURI.

----	----	5.02	----	F. E. Nipher.	St. Louis Acad. Sc.
----	----	5.01	----	Do.	Do.
----	67.08	5.03	12.92	Do.	Do.
----	67.63	4.95	13.01	Do.	Do.
----	67.47	4.94	12.89	Do.	Do.
----	67.44	5.00	13.03	Do.	Do.
----	67.03	5.11	13.10	Do.	Do.
----	67.12	5.03	12.94	Do.	Do.
----	67.71	4.96	13.08	Do.	Do.
----	67.70	4.99	13.15	Do.	St. Louis Acad. Sc., Vol. IV.
----	} 69.84	4.60	13.35	Do.	St. Louis Acad. Sc.
----				Do.	Do.
----	67.83	4.95	13.12	Do.	St. Louis Acad. Sc., Vol. IV.
----	67.88	4.95	13.15	Do.	St. Louis Acad. Sc.
----	} 67.78	4.97	13.15	Do.	Do.
----				Do.	Do.
----	68.40	4.89	13.28	Do.	Do.
----	68.16	4.86	13.06	Do.	St. Louis Acad. Sc., Vol. IV.
----	68.16	4.90	13.17	Do.	St. Louis Acad. Sc.
----	68.16	4.89	13.15	Do.	Do.
----	68.08	4.90	13.13	Do.	St. Louis Acad. Sc., Vol. IV.
----	68.61	4.79	13.13	Do.	St. Louis Acad. Sc.
----	68.22	4.93	13.29	Do.	St. Louis Acad. Sc., Vol. IV.
----	68.54	4.79	13.09	Do.	Do.
----	68.02	4.90	13.09	Do.	Do.
----	68.67	4.80	13.20	Do.	Do.
----	68.26	4.87	13.15	Do.	Do.
----	68.89	4.80	13.33	Do.	Do.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MISSOURI—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip	Horizontal force H.
	° /	° /			° /	
Wulfert's farm.	38 24	91 16	1881	July 15.	----	4.794
Union.	38 25	90 59	1881	July 8.	68 56.2	4.765
Versailles.	38 25	92 53	1881	July 25.	68 45.2	4.796
Meramec River.	38 26	90 12	1819	June 8.	70 00	----
Pacific.	38 28.2	90 43.8	1880	July 27.	69 02.3	4.722
Washington.	38 31.2	90 58.9	1879	Aug. 15.	69 07.6	4.737
Windsor.	38 32	93 33	1881	Aug. 9.	68 26.2	4.820
Jefferson City.	38 34.8	92 09.0	1879	Aug. 10-13.	68 55.7	4.744
Cote sans dessein.	38 36	91 56	1819	July 6.	70 50	----
St. Louis.	38 36	90 12	1819	June 16.	70 30	----
Saint Louis, H. Chauteau's garden.	38 37.5	90 12.0	{ 1835 1836	{ Aug. June. }	69 10	4.814
St. Louis.	38 38	90 12	1839	Sept. 6.	69 31.4	4.748
St. Louis, 1 mile west of city.	38 38	90 12	1841	Sept.	69 25.5	----
St. Louis, H. Chauteau's orchard about ½ mile from river.	38 37.5	90 12.0	1841	Oct. 11.	69 27.1	----
Saint Louis.	38 38	90 12	1856	Nov. 1.	68 01	4.925
Saint Louis, Compton Hill.	38 37.1	90 14.0	1872	June, July.	69 34.4	4.629
Saint Louis, three different localities.	38 38.0	90 12.3	1878	May 27, 28, 30.	69 18.7	----
Saint Louis, Washington Avenue and Eight- eenth street.	38 38	90 12	1878	July 10; Oct. 11.	----	4.586
Saint Louis.	38 38.0	90 12.3	1879	Sept. 3, 9.	---	4.673
Holden.	38 37.8	94 03.0	1879	Aug. 17, 19.	68 29.3	4.848
California.	38 39	92 38	1881	Aug. 22.	68 46.7	4.743
Zimmerman's place.	38 41	93 34	1881	Aug. 10, 11.	68 13.2	4.938
Near Clayton, Saint Charles' Rockroad.	38 41	90 19	1881	July 4.	----	4.601
Hermann, on hill southeast of depot.	38 42	91 27	1872	Sept. 29.	69 21.3	4.666
Sedalia, ¼ mile south of depot.	38 42	93 13	1872	Oct. 2.	68 48.5	4.780
Sedalia.	38 42.2	93 15.5	1878	Sept. 7, 8.	68 54.7?	4.715 (?)
Do.	38 42.2	93 15.5	1879	Aug. 8.	68 49.7	4.813
Marion.	38 42	92 25	1881	Aug. 26.	68 48.1	4.750
Dardenne.	38 43	90 42	1881	Sept. 3.	69 02.7	4.757
Bellefontaine.	38 43	90 12	1819	June 23.	70 00	----
Pattonsville, opposite Saint Charles.	38 43	90 30	1881	Sept. 4, 6.	69 39.6	4.612
Opposite Saint Charles.	38 44	90 31	1881	Sept. 4.	70 08.0	4.512
Saint Charles.	38 46	90 28	1819	June 25.	70 05	----
Do.	38 45.0	90 29.8	1878	July 10, 11.	69 29.9	4.497

*intensities in the United States and adjacent regions.—Continued.*

## MISSOURI—Continued.

Total force	Referred results.			Observer.	Reference and remarks.
	F.	$\theta_{1885.0}$	H <sub>1885.0</sub>	F <sub>1885.0</sub>	
		o			
----	----	4.79	----	F. E. Nipher.	St. Louis Acad. Sc., Vol. IV.
----	68.82	4.77	13.20	Do.	Do
----	68.63	4.80	13.17	Do.	Do
----	68.7	----	----	S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838, Loomis. Applied correction of + 36' to longitude.
----	68.89	4.72	13.10	F. E. Nipher.	St. Louis Acad. Sc.
----	68.95	4.74	13.20	F. E. Nipher.	St. Louis Acad. Sc.
----	68.32	4.82	13.04	Do.	St. Louis Acad. Sc., Vol. IV.
----	68.75	4.74	13.08	Do.	St. Louis Acad. Sc.
----	69.5	----	----	S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Loomis.
----				Do.	Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Loomis. Applied Cor'n of + 36' to longitude.
----				J. N. Nicollet.	C. S. Rpt., 1864; $\theta$ = mean value, 1835 Aug. & 1836 June, Epoch 1836.0.
13.58				J. Locke.	Sill. J., Vol. XXXIX, 1840; Am. Phil. Soc., 1846, Art. XI.
----				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----				J. N. Nicollet.	Do.
13.147	69.17	4.63	13.02	K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. Intensities converted into Eng. units. The dip appears to be defective.
----				T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----				F. E. Nipher.	St. Louis Acad. Sc. Mean of 3 values.
----				Do.	St. Louis Acad. Sc. Five stations occupied, of which Sta. 2 apparently least affected by local disturbance.
----				Do.	St. Louis Acad. Sc.
----	68.31	4.85	13.13	Do.	Do.
----	68.66	4.74	13.03	Do.	St. Louis Acad. Sc., Vol. IV.
----	68.10	4.94	13.24	Do.	Do.
----		4.60	----	Do.	Do.
----	69.03	----	----	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----				Do.	Do.
----	68.61	4.81	13.19	F. E. Nipher.	St. Louis Acad. Sc.
----				Do.	Do.
----	68.68	4.75	13.07	Do.	St. Louis Acad. Sc., Vol. IV.
----	68.92	4.76	13.23	Do.	Do.
----	69.3	----	----	S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Loomis. Longitude cor'd by + 36'.
----				F. E. Nipher.	St. Louis Acad. Sc.
----				Do.	St. Louis Acad. Sc., Vol. IV.
----	69.60	4.51	12.94	S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Applied cor'n of + 40' to longitude.
----				F. E. Nipher.	St. Louis Acad. Sc.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MISSOURI—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	$^{\circ}$ /	$^{\circ}$ /			$^{\circ}$ /	
Warrenton.	38 46	91 08	1881	Sept. 2.	69 10.4	4.697
O'Fallon.	38 46.8	90 43.2	1880	Oct. 31.	----	4.670
Florissant.	38 47	90 17	1881	Sept. 6.	----	4.608
Wright City.	38 47.1	91 00	1878	July 12.	69 11.2	4.616
Providence.	38 49	92 28	1881	Aug. 27.	69 00.3	4.737
Clark's Fork.	38 51	92 40	1881	Aug. 20.	69 15.9	4.724
Sweet Springs.	38 55	93 29	1881	Aug. 13.	68 57.4	4.753
Columbia.	38 56.5	92 20.2	1878	July 15, 17.	69 19.1	4.670
Franklin.	38 57	92 57	1819	July 17.	69 30	----
McCredie.	38 59	91 55	1881	Aug. 30.	69 05.0	4.717
Herndon.	39 00	93 21	1881	Aug. 15.	----	4.734
Arrow Rock.	39 06	93 00	1881	Aug. 18.	----	4.653
Camp on Missouri River.	39 06	93 00	1819	July 28.	69 45	----
Kansas City.	39 05	94 38	1872	Oct. 4.	69 05.3	4.773
Do.	39 07.2	94 37.7	1878	Sept. 3, 4, 6.	69 13.8	4.627
Do.	39 07.2	94 37.7	1879	July 29.	68 58.6	4.783
Marshall.	39 08	93 17	1881	Aug. 16.	69 34.0	4.660
Charaton.	39 10	92 20	1819	July 24.	69 50	----
Fort Osage.	39 10	94 18	1819	Aug. 4.	69 18	----
Mexico.	39 11.1	91 52.1	1878	July 13.	69 27.6	4.728
Lexington.	39 11.5	93 52.9	1879	Aug. 21, 22.	69 13.7	4.712
Glasgow.	39 13.3	92 49.6	1879	July 21, 22.	69 57.4	4.575
Carrollton.	39 21.1	93 32.8	1879	July 28.	69 29.0	4.680
Cow Island.	39 25	94 00	1819	Aug. 20.	69 50	----
Louisiana.	39 27.2	91 03.1	1878	Nov. 20, 21, 22.	69 57.7	----
Do.	39 28.0	91 06.7	1878	July 20, 21.	69 50.2	4.576
Hannibal.	39 44.1	91 23.7	1878	July 22.	70 14.3	4.525
St. Joseph.	39 45.6	94 49.2	1879	July 31.	69 43.3	4.657
Macon.	39 46.4	92 29.6	1878	Aug. 6.	70 07.6	4.521
Chillicothe.	39 47.4	93 34.5	1879	July 25.	70 19.3	4.527
Canton.	40 08.6	91 35.6	1878	July 24, 27.	70 27.8	4.442
Kirksville.	40 11.7	92 36.7	1878	Aug. 3, 5.	70 40.6	4.416
Memphis.	40 27.3	92 13.3	1878	Aug. 1, 2.	70 26.8	4.477
Marysville.	40 21.0	94 57.5	1879	Aug. 2, 3, 4.	70 05.8	4.538

*intensities in the United States and adjacent regions.—Continued.*

## MISSOURI—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°				
----	69.05	4.70	13.15	F. E. Nipher.	St. Louis Acad. Sc., Vol. IV.
----	----	4.67	----	Do.	St. Louis Acad. Sc.
----	----	4.61	----	Do.	St. Louis Acad. Sc., Vol. IV.
----	68.98	4.62	12.88	Do.	St. Louis Acad. Sc.
----	68.88	4.74	13.16	Do.	St. Louis Acad. Sc., Vol. IV.
----	69.14	4.72	13.26	Do.	Do.
----	68.84	4.75	13.16	Do.	Do.
----	69.10	4.67	13.09	Do.	St. Louis Acad. Sc.
----	68.8	----	----	S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.)
----	66.96	4.72	12.06	F. E. Nipher.	St. Louis Acad. Sc., Vol. IV.
----	----	4.73	----	Do.	Do.
----	} 69.0	4.65	12.98 {	F. E. Nipher.	Do.
----				S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.) Longitude apparently doubtful.
----	----	----	----	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	} 68.88	4.72	13.10 {	F. E. Nipher.	St. Louis Acad. Sc.
----				Do.	Do.
----	69.45	4.66	13.28	Do.	St. Louis Acad. Sc., Vol. IV.
----	69.1	----	----	S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.) Longitude apparently doubtful.
----	68.6	----	----	Do.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.)
----	69.24	4.73	13.35	F. E. Nipher.	St. Louis Acad. Sc.
----	69.05	4.71	13.17	Do.	Do.
----	69.78	4.58	13.25	Do.	Do.
----	69.30	4.68	13.24	Do.	Do.
----	69.1	----	----	S. H. Long, U. S. A.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.)
----	} 69.68	4.58	13.19 {	C. F. Powell.	U. S. Lake Sur. Rpt., 1879.
----				F. E. Nipher.	St. Louis Acad. Sc.
----	70.02	4.53	13.26	Do.	Do.
----	69.54	4.66	13.33	Do.	Do.
----	69.92	4.52	13.17	Do.	Do.
----	70.14	4.53	13.34	Do.	Do.
----	70.25	4.44	13.14	Do.	Do.
----	70.46	4.42	13.21	Do.	Do.
----	70.23	4.48	13.25	Do.	Do.
----	69.92	4.54	13.23	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

## MONTANA.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	° /	° /			° /	
Fort Ellis.	45 40	110 58	1882	Aug. 30.	71 43.4	4.248
Fort Custer.	45 45	107 48	1882	July 23.	72 23.4	4.167
South Crossing, Kootenay River.	48 22	115 21	1861	July 6.	72 48.1	3.973 <sup>1</sup>
Kootenay River.	48 40	115 17	1861	July 12.	73 07.2	----
Tobacco Plains, Kootenay.	48 57	115 08	1861	Aug. 19.	73 22.9	----
Camp Kootenay East.	48 59	115 12	1861	----	73 11	3.850
Camp Kishenehu.	49 00	114 21	1861	----	73 46.8	3.790

## NEBRASKA.

Big Sandy River.	40 12	97 12	1858	Aug.	69 33	----
Little Blue River.	40 15	98 10	1858	Aug.	69 51	----
Fort Kearney.	40 38	98 56	1858	Sept.	70 15	----
Camp No. 20.	40 40	99 54	1858	Sept.	69 37	----
Grand Island, $\frac{3}{4}$ mile N. W. of depot.	40 55	98 23	1872	Oct. 27.	70 15.5	4.535
Grand Island.	40 55.4	98 17.6	1878	Aug. 28.	70 17.7	4.5675
Camp No. 22.	41 05	100 50	1858	Sept.	69 46	----
Sidney.	41 08	102 55	1872	Oct. 25.	69 23.9	4.640
North Platte.	41 11	100 45	1872	Oct. 26.	69 41.1	4.585
Omaha.	41 15.7	95 56.5	1869	Jan. 25-Feb. 1.	71 04.5	4.314
Omaha, on hill southwest of Brownell School.	41 16	95 56	1872	Oct. 31.	71 06.1	4.320
Omaha.	41 15.7	95 56.5	1877	Oct. 13-20.	71 05.8	4.408
Do.	41 15.7	95 56.5	1880	Oct. 15, 17.	71 05.9	4.375
Ash Hollow.	41 21	102 03	1858	Sept.	70 03	----
Chimney Rock.	41 43	103 30	1858	Sept.	70 05	----

## NEVADA.

Pioche.	37 59.1	114 03.1	1883	Sept. 24-28.	65 36	5.162
White Pine Station.	38 19.1	115 30.1	1881	Nov. 14-23.	64 04.1	5.389
Jeff. Davis.	38 59.1	114 18.8	1882	Nov. 19-23.	64 59.9	5.270
Genoa, Carson Valley.	39 00	119 40	1859	----	64 12	----
Tres Pinos, Lehman's Cañon.	39 00.5	114 14.1	1882	Dec. 1, 2, 3.	65 00.8	5.273
Lehman's Ranch, Snake Valley.	39 00.6	114 08.2	1882	Dec. 9, 10, 11.	65 02.4	5.287
Big Bend, Walker's River.	39 09	118 56	1859	----	63.37	----
Carson Lake.	39 24	118 30	1859	----	64 02	----
Austin, hill back of Chinatown.	39 28.9	117 04.0	1881	May 31; June 1, 2.	64 49.0	5.254
Reese River. *	39 29	117 03	1858	----	64 25	----
Reno, near Court-House.	39 30.5	119 48.7	1881	Apr. 11, 12, 13.	64 14.1	5.317

\* Dip changed from 69° 25' to 64° 25' for supposed printing error.

*intensities in the United States and adjacent regions—continued.*

## MONTANA.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
13.546	71.70	4.25	13.54	B. A. Colonna.	MS. in C. & G. S. Office.
13.774	72.36	4.17	13.76	Do.	Do.
13.435	72.8	----	----	R. W. Haig.	B. S.; Phil. Trans. R. S., 1864. $\theta$ , H, F, obs'd.
13.443	73.1	----	----	Do.	Do.
13.477	73.3	----	----	Do.	Do.
----	73.3	----	----	J. S. Harris.	U. S. NW. Bound. Com.; MS. in C. S. Office.
----	73.7	----	----	Do.	Do.

## NEBRASKA.

----	69.6	----	----	J. H. Simpson.	J. B. Stone's "Magnetic Variation," New York, 1878.
----	69.8	----	----	Do.	Do.
----	70.2	----	----	Do.	Do.
----	69.6	----	----	Do.	Do.
13.546	70.28	4.56	13.52	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
----	69.8	----	----	T. E. Thorpe.	Proc. R. S., No. 200, 1880.
----	69.4	4.64	13.19	J. H. Simpson.	J. B. Stone's "Magnetic Variation," New York, 1878.
----	69.7	4.59	13.23	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
13.30	71.05	4.39	13.52	Do.	Do.
----	71.05	4.39	13.52	E. Goodfellow.	C. & G. S. Rpt., 1881, App. 9.
13.61	71.05	4.39	13.52	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14.
13.50	71.05	4.39	13.52	A. Braid.	C. & G. S. Rpt., 1881, App. 9.
----	70.0	----	----	J. B. Baylor.	Do.
----	70.1	----	----	J. H. Simpson.	J. B. Stone's "Magnetic Variation," New York, 1878.
----	70.1	----	----	Do.	Do.

## NEVADA.

12.50	65.5	5.158	12.44	W. Eimbeck and G. F. Bird.	MS. in C. & G. S. Office.
12.32	64.0	5.381	12.28	W. Eimbeck and R. A. Marr.	C. & G. S. Rpt., 1881, App. 9.
12.47	64.9	5.264	12.41	Do.	MS. in C. & G. S. Office.
----	----	----	----	J. H. Simpson.	Mag. Var., by J. B. Stone, New York, 1878.
12.48	65.0	5.275	12.48	W. Eimbeck and R. A. Marr.	MS. in C. & G. S. Office.
12.53	65.0	5.275	12.48	Do.	Do.
----	----	----	----	J. H. Simpson.	Mag. Var., by J. B. Stone, New York, 1878.
----	----	----	----	Do.	Do.
12.34	64.8	5.245	12.32	W. Eimbeck and R. A. Marr.	C. & G. S. Rpt., 1881, App. 9.
----	64.8	5.245	12.32	J. H. Simpson.	Mag. Var., by J. B. Stone, New York, 1878.
12.23	64.2	5.308	12.20	W. Eimbeck and R. A. Marr.	C. & G. S. Rpt., 1881, App. 9.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEVADA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Verdi.	39 31.1	119 57.8	1872	July 28, 29.	63 58.6	5.303 (?)
Eureka, town, on Story's Hill.	39 31.1	115 58.2	1881	May 19, 21, 22.	65 08.4	5.218
Eureka Station.	39 35.1	115 49.1	1881	Sept. 13-29.	65 12.3	5.209
Mount Callahan Station.	39 42.6	116 57.0	1881	July 12, 20.	65 07.4	5.221
Ko-bah Valley.	39 44	116 10	1858	----	64 56	----
Hot Springs, opposite railroad office.	39 46.9	118 55.5	1881	Apr. 15, 16.	64 46.5	5.271
Antelope Valley.	39 47	114 12	1859	----	65 16	----
Cho-Keep Pass.	39 54	115 45	1858	----	65 19	----
Huntingdon's Spring.	40 01	115 19	1859	----	65 25	----
Mineral Hill.	40 09.8	116 12.0	1881	May 23, 24, 25.	65 40.7	5.151
Rye Patch, north of railroad office and hotel.	40 26.0	118 18.5	1881	Apr. 18, 19.	65 23.9	5.159
Battle Mountain, hotel garden.	40 40.3	116 50.0	1881	Apr. 23, 24, 25.	65 51.2	5.116
Elko, grounds of Nevada State University.	40 47.4	115 45.5	1881	Apr. 26, 27, 28.	66 23.0	5.043
Winnemucca, near court-house.	40 58.9	117 44.0	1881	Apr. 21, 22.	65 59.2	5.114
Wells' Station, near public school building.	41 07.0	114 56.0	1881	Apr. 29, 30.	66 49.9	4.989
Tecoma, near Peck's Hotel.	41 19.5	114 06.0	1881	May 1, 2.	67 08.0	4.947

## NEW HAMPSHIRE.

Troy.	42 49.7	72 10.9	1861	Aug. 19-22.	74 45.7	3.578
Monadnock.	42 51.7	72 06.5	1861	July 31; Aug. 2, 3.	74 44.4	----
Chesterfield, about one mile east of factory village.	42 54.0	72 26.0	1874	Oct. 4.	74 24.7	3.599
Isles of Shoals, Hog Island.	42 59.2	70 36.8	1847	Aug. 17, 18, 26, 27.	74 44.1	3.482
Unkonooc.	42 59.0	71 35.3	1848	Oct. 9, 10.	75 08.7	3.476
Portsmouth.	43 04.5	70 44	1844	----	74 51.0	----
Portsmouth, Jamaica Island.	43 04.5	70 44	1844	----	74 47.7	----
Portsmouth, near North Base.	43 03	70 44	1844	----	74 38.0	----
Portsmouth, Shelliby's field.	43 04	70 47	1844	----	74 53.7	----
Portsmouth.	43 04	70 45	1844	----	74 58.2	----
Portsmouth, on Tree Island.	43 04.5	70 45	1844	----	74 57.4	----
Patuccawa.	43 07.2	71 11.8	1849	Aug. 15-19.	76 49.5	3.093
Gunstock.	43 31.1	71 22.2	1860	July 25; Aug. 4.	75 43.6	3.401
Hanover.	43 42.3	72 17.1	1873	Oct. 4-10.	75 21.1	3.455
Hanover, hill north of observatory.	43 42.3	72 17.1	1879	Oct. 6.	74 55.8	3.478
Hanover, about $\frac{3}{4}$ mile west of observatory.	43 42.3	72 18.0	1879	Oct. 7.	75 02.7	3.473
Near Mount Washington.	44 15	71 18	1845	June.	75 40.0	----
Mount Washington.	44 16.2	71 18.2	1845	June 18.	75 45.0	3.314
Camp on Mount Washington, 1 mile west of summit.	44 16	71 19	1845	June 19.	75 50.8	3.316

*intensities in the United States and adjacent regions—Continued.*

## NEVADA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
12. 59(?)	(63. 9)	5. 267	(11. 97)	G. Davidson and S. R. Throckmorton.	C. & G. S. Rpt., 1881, App. 9.
12. 41	65. 1	5. 209	12. 37	W. Eimbeck and R. A. Marr.	Do.
12. 42	65. 1	5. 201	12. 35	Do.	Do.
12. 41	65. 1	5. 212	12. 38	Do.	Do.
----	----	----	----	J. H. Simpson.	Mag. Var., by J. B. Stone, New York, 1878.
12. 37	64. 7	5. 262	12. 31	W. Eimbeck and R. A. Marr.	C. & G. S. Rpt., 1881, App. 9.
----	----	----	----	J. H. Simpson.	Mag. Var., by J. B. Stone, New York, 1878.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
12. 51	65. 6	5. 142	12. 45	W. Eimbeck and R. A. Marr.	C. & G. S. Rpt., 1881, App. 9.
12. 39	65. 4	5. 150	12. 37	Do.	Do.
12. 51	65. 8	5. 107	12. 46	Do.	Do.
12. 59	66. 3	5. 034	12. 52	Do.	Do.
12. 57	65. 9	5. 105	12. 50	Do.	Do.
12. 68	66. 7	4. 980	12. 59	Do.	Do.
12. 73	67. 0	4. 938	12. 64	Do.	Do.

## NEW HAMPSHIRE.

13. 61	73. 76	3. 690	13. 20	G. W. Dean, R. E. Halter, and A. D. Bache.	C. & G. S. Rpt., 1881, App. 9.
----	73. 74	----	----	Do.	Do.
13. 39	73. 68	3. 640	12. 95	T. C. Hilgard.	Do.
13. 22	73. 83	3. 564	12. 80	T. J. Lee.	Do.
13. 56	74. 23	3. 567	13. 13	J. S. Ruth.	Do.
----	73. 98	----	----	J. D. Graham.	Sill. J., Vol. IV, 1847.
----				J. D. Graham and A. W. Whipple.	Phil. Trans. R. S., 1846.
----				Do.	Do.
----				Do.	Do.
----				Do.	Do.
13. 57	75. 91	3. 19	13. 12	C. O. Boutelle.	C. & G. S. Rpt., 1881, App. 9.
13. 80	74. 73	3. 518	13. 36	G. W. Dean and A. D. Bache.	Do.
13. 66	74. 56	3. 497	13. 14	T. C. Hilgard.	Do.
13. 38				J. B. Baylor.	Do.
13. 46				Do.	Do.
13. 47	74. 88	3. 381	12. 96	J. Locke.	Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852.
13. 47				Do.	Do.
----	----	----	----	Do.	Do.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW HAMPSHIRE—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	$^{\circ}$ /	$^{\circ}$ /			$^{\circ}$ /	
Fabyan Hotel, 7 miles west of Mount Wash- ington.	44 16	71 25	1845	June 20.	75 39.9	3.336
Glen House, 4 miles east of Mount Wash- ington.	44 16	71 14	1856	Aug. 11.	75 56	----
Littleton, on rock near Oak Hill House.	44 19.0	71 48.0	1873	Sept. 28-Oct. 1.	75 39.1	3.378
Gorham, at Soldiers' Hill.	44 22.5	71 15.0	1873	Sept. 20-25.	75 35.6	3.410
Gorham.	44 27	71 13	1845	June 17.	75 33.4	3.385
Hall's stream.	45 01	71 30	1845	----	76 23.5	----

## NEW JERSEY.

Cape May light-house.	38 55.8	74 58.0	1846	June 29.	71 25.8	4.255
Do.	38 55.8	74 58.0	1855	Aug. 3.	71 34.4	4.182
Do.	38 55.8	74 58.0	1874	June 27.	71 28.5	4.283
Townbank.	38 58.6	74 57.7	1846	June 30.	71 23.6	4.269
Egg Island light-house.	39 10.5	75 08.4	1846	June 25.	71 45.1	4.206
Port Norris.	39 14.6	75 01.3	1846	June 23.	71 39.6	4.211
Atlantic City.	39 21.8	74 24.9	1860	Aug. 22, 23.	71 47.0	4.205
Pine Mount.	39 25.0	75 20.3	1846	June 19.	71 41.4	4.237
Hawkins.	39 25.6	75 17.3	1846	June 20.	71 42.6	4.224
Long Beach.	39 32.0	74 15.6	1860	Aug. 24-28.	71 58.5	4.156
Tuckerton.	39 36.1	74 19.8	1846	Nov. 7, 9.	72 12.3	4.063
Church Landing.	39 40.6	75 31.3	1846	June 6.	71 22.0	4.311
Barneget light-house.	39 45.8	74 06.4	1860	Aug. 25, 26.	72 05.3	4.108
Chew.	39 48.2	75 10.1	1846	July 14, 15.	72 14.4	4.105
White Hill.	40 08.3	74 43.9	1846	May 20.	72 06.2	4.147
Trenton.	40 13	74 45	1841	Apr. 23.	71 59	4.196
Princeton College.	40 20.9	74 39.6	1839	Sept.	72 47.1	4.041
Princeton, in field behind college.	40 21	74 40	1842	Oct. 14.	72 43.5	4.010
Princeton, near college.	40 20.7	74 39.6	1843	July.	72 38.3	4.222
Do.	40 20.9	74 39.6	1844	----	72 39.5	----
Do.	40 20.9	74 39.6	1844	May 23.	72 40.2	4.016
Princeton, Pott's Wood.	40 22	74 39	1844	May 23, 24.	{ 72 41.4 72 41.2	{ 4.017 3.999
Princeton, Rocky Hill (Trap).	40 23	74 39	1844	May 24.	72 35.0	4.049
Mount Rose.	40 22.2	74 43.3	1852	Aug. 12-18.	72 42.5	4.130
Sandy Hook.	40 27.7	74 00.2	1844	Aug.	72 37.9	4.077
Do.	40 27.7	74 00.3	1855	Aug. 14.	72 52.0	3.917
Do.	40 27.7	74 00.2	1873	Nov. 5-9.	72 29.6	4.040
Do.	40 27.7	74 00.2	1879	July 17, 18.	72 08.3	4.078

*intensities in the United States and adjacent regions.—Continued.*

## NEW HAMPSHIRE—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°				
----	74.79	3.402	12.97	J. Locke.	Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852.
----	74.95	----	----	K. Fric-sach.	K. K. Acad. d. Wiss., Vienna, Vol. 29, 1858.
13.63	74.88	3.423	13.12	T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
13.70	74.76	3.454	13.14	Do.	Do.
13.58				J. Locke.	Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852.
----	75.52	----	----	J. D. Graham.	Phil. Trans. R. S., 1846.

## NEW JERSEY.

13.36	70.99	4.304	13.21	J. Locke.	C. & G. S. Rpt., 1881, App. 9.
13.23				C. A. Schott.	Do.
13.48				T. C. Hilgard.	Do.
13.38	70.88	4.334	13.23	J. Locke.	Do.
13.43	71.24	4.271	13.28	Do.	Do.
13.38	71.15	4.276	13.24	Do.	Do.
13.45	71.18	4.288	13.29	C. A. Schott.	Do.
13.49	71.18	4.296	13.32	J. Locke.	Do.
13.46				Do.	Do.
13.43	71.37	4.240	13.27	C. A. Schott.	Do.
13.30	71.69	4.129	13.14	T. J. Lee.	Do.
13.49	70.86	4.377	13.35	J. Locke.	Do.
13.36	71.49	4.191	13.20	C. A. Schott.	Do.
13.46	71.73	4.171	13.31	J. Locke.	Do.
13.50	71.59	4.213	13.34	Do.	Do.
13.56	71.46	4.242	13.34	Do.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13.55	72.17	4.110	13.42	E. Loomis.	Sill. J., Vol. XXXIX, 1840; Am. Phil. Soc., Vol. VIII.
13.504				J. H. Lefroy.	Diary Mag. Sur. Canada, Gen'l Sir J. H. Lefroy, London, 1883.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	72.16	4.211	13.75	E. Loomis.	Phil. Trans. R. S., 1846.
13.48				J. Locke.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13.50				Do.	Do.
13.44	71.93	4.081	13.16	Do.	Do.
13.53				Do.	Do.
13.90				J. E. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
13.66	71.93	4.081	13.16	J. Renwick.	Do.
13.30				C. A. Schott.	Do.
13.43				T. C. Hilgard.	Do.
13.30				J. B. Baylor.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW JERSEY—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
New Brunswick.	40 29.9	74 26.8	1844	May 24.	72 43.2	4.008
Snake Hill, seven miles west of New York.	40 43	74 06	1844	Apr.	72 45.4	----
Newark.	40 44	74 10	1841	Apr. 19.	72 48.5	3.999
Newark, Washington place.	40 44	74 10	1844	Apr. 29.	72 50.2	3.972
Newark, on the Neck.	40 44	74 09	1844	Apr. 29.	72 46.3	3.986
Newark.	40 44.8	74 10.0	1846	May 16.	72 52.2	3.964
Fort Lee.	40 50.8	73 57.7	1844	Apr.	72 41	----
Paterson.	40 56	74 10	1844	Apr.	{ 72 17 to 75 00 }	{ ---- }

## NEW MEXICO.

San Luis Springs.	31 20	108 48	1855	Apr. 19.	57 37	6.265
Agua del Perro.	31 21	108 20	1855	Apr. 3.	57 28	6.156
El Paso del Norte, Initial Point.	31 47	106 28	1855	Jan. 4.	58 39	6.202
Carrizalillo.	31 51	107 56	1855	March 1.	58 31	6.125
Dofia Ana.	32 22	106 47	1851	----	59 06	----
IX.	32 22	107 24	1851	----	59 09	----
Ojo de Inez.	32 45	108 14	1851	----	59 18	----
Copper Mines.	32 47	108 04	1851	----	59 17	----
Isleta.	34 54	106 40	1853	Nov. 9.	62 24	----
Rio San José.	35 01	107 14	1853	Nov. 12.	63 18	----
Cedar Forest.	35 01	108 55	1853	Nov. 28.	61 40	----
Agua Fria.	35 02	107 58	1883	Nov. 17.	62 05	----
Prescription Rock, north bluff of El Moro.	35 03	108 14	1853	Nov. 18.	62 03	----
Covero.	35 05	107 26	1853	Nov. 14.	62 26	----
Hay Camp, south side of stream.	35 05	107 39	1853	Nov. 15.	62 39	----
Arch Spring.	35 05	108 48	1853	Nov. 26.	61 55	----
Albuquerque.	35 06	106 38	1853	Oct. 17.	62 28	----
Zuni River.	35 06	108 39	1853	Nov. 22.	62 02	----

## NEW YORK.

Cole, Staten Island, geodetic station.	40 31.9	74 14.1	1846	May 11.	72 34.2	4.028
Fire Island light-house, Long Island.	40 37.9	73 13.2	1848	July 15.	----	3.932
Fire Island, west end of Fire Island base.	40 37.8	73 12.9	1860	Sept. 1, 2.	73 00.2	3.900
New York, Columbia College (old site).	40 42.6	74 00.5	1822	Dec.	73 00.5	3.981
New York.	40 43	74 01	1825	March.	73 27.0	----
Do.	40 42.6	74 00.5	1831	Apr. 19.	73 00	----

*intensities in the United States and adjacent regions.—Continued.*

## NEW JERSEY—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13.50	72.21	4.066	13.31	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	72.25	----	----	Do.	Am. Phil. Soc., 1846, Vol. IX.
13.54	72.31	4.037	13.29	Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13.46				Do.	Do.
13.46				Do.	Do.
13.46				Do.	C. & G. S. Rpt., 1881, App. 9.
----	72.17	----	----	Do.	Am. Phil. Soc., 1846, Vol. IX.
----	----	----	----	Do.	Do.

## NEW MEXICO.

11.70	----	6.21	----	W. H. Emory.	U. S. & Mex. Bound. Sur., Am. Acad. Sc., Vol. VI, 1856.
11.45	----	6.10	----	Do.	Do.
11.92	----	6.15	----	Do.	Do.
11.73	----	6.07	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
12.54	----	5.76	----	J. C. Ives and A. W. Whipple.	C. S. Rpt., 1856, p. 222.
12.56	----	5.59	----	Do.	Do.
12.49	----	5.87	----	Do.	Do.
12.55	----	5.82	----	Do.	Do.
12.49	----	5.80	----	Do.	Do.
12.56	----	5.76	----	Do.	Do.
11.64	----	----	----	Do.	Do.
12.51	----	5.84	----	Do.	Do.
12.56	----	5.75	----	Do.	Do.
12.51	----	5.81	----	Do.	Do.

## NEW YORK.

13.45	71.88	4.101	13.19	J. Locke.	C. & G. S. Rpt., 1881, App. 9.
----	72.20	4.012	13.12	J. S. Ruth.	Do.
13.34				C. A. Schott.	Do.
13.62				E. Sabine.	Sill. J., 1838 & 1842. E. Loomis; Brit. Asso. Rpt., Vol. VI, 1838; C. S. Rpt., 1861.
----				J. Franklin.	Sill. J., 1838 & 1842. E. Loomis.
----	----	----	----	Joslyn.	Sill. J., Vol. XXII, 1832.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW YORK—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	° /	° /			° /	
New York.	40 43	74 01	1833	April.	$\left. \begin{matrix} 73 \text{ } 49.3 \\ 72 \text{ } 14 \end{matrix} \right\}$	----
New York, Columbia College (old site).	40 42.6	74 00.5	1834	Aug.	72 51.7	----
Do.	40 42.6	74 00.5	1835	----	----	3.973
Do.	40 43	74 01	1839	Sept.	72 52.2	4.012
Do.	40 42.6	74 00.5	1841	Apr. 19.	72 41	4.022
New York.	40 46.1	76 56.5	1841	Dec.	72 39.6	4.014
New York, Columbia College (old site).	40 42.6	74 00.5	1842	----	72 37.2	4.030
Do.	40 42.6	74 00.5	1844	Apr. 27.	72 42.6	4.007
Do.	40 42.6	74 00.5	1844	Aug. 8–31.	72 37.8	4.071
New York.	40 43	74 01	1844	----	72 28.9	----
New York, Columbia College (old site).	40 42.6	74 00.5	1845	Sept. 4.	72 40.6	----
Flatbush, Mount Prospect, Brooklyn.	40 40.3	73 58.0	1846	May 6.	72 27.6	4.054
New York.	40 41	74 02	1846	Nov.	72 39.3	----
New York, Rutherford's observatory.	40 43.9	73 59.2	1853	May 19.	72 55.6	----
New York, Governor's Island.	40 41.5	74 01.1	1855	Aug. 7.	72 46.3	3.926
New York, Bedloe's Island.	40 41.4	74 02.7	1855	Aug. 8.	72 59.2	3.920
New York, receiving reservoir, Central Park.	40 46.7	73 58.2	1855	Aug. 10.	72 44.4	3.938
Flatbush, Mount Prospect, Brooklyn.	40 40.3	73 58.0	1860	Sept. 20–22.	72 40.8	4.052
New York, Central Park.	40 46.2	73 58.2	1872	Nov. 1–4.	72 35.8	3.982
New York, new asylum, New Harlem.	40 49	73 58	1841	Apr. 20.	72 21	4.099
New York, Bloomingdale Asylum, Manhattan-ville.	40 50.3	73 56.7	1841	Apr. 20.	72 39.6	4.019
Do.	40 50.3	73 56.7	1842	Sept. 26.	72 35.6	4.008
Do.	40 50.3	73 56.7	1844	Apr. 26.	72 41.7	4.005
Do.	40 50.3	73 56.7	1844	Sept. 3.	72 49.5	4.008
Do.	40 50.3	73 56.7	1846	Apr. 27, 30.	72 39.0	4.009
Patchogue, west of Ocean House.	40 44.9	73 01.5	1875	July 30–Aug. 5.	72 45.4	3.968
Legget, geodetic station.	40 48.9	73 53.5	1847	Oct. 15–20.	72 52.7	3.976
West Hills, about 200 metres north and east of geodetic station.	40 48.9	73 25.5	1865	Aug. 10–21.	72 56.8	3.930
Ruland.	40 50.7	73 02.0	1865	May 25–June 6.	72 54.9	3.945
Oyster Bay.	40 52.3	73 31.6	1844	Sept. 16, 17.	72 58.5	3.894
New Rochelle, south of Neptune House.	40 52.5	73 47.3	1844	Sept. 10.	72 44.0	3.845
Lloyd Harbor, Huntington.	40 55.6	73 25.1	1844	Sept. 15.	72 50.6	3.857

*intensities in the United States and adjacent regions.—Continued.*

NEW YORK—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°			Back.	Sill. J., 1838 & 1842. E. Loomis. In Encyc. Brit., 7th ed., 1842, $\theta = 73^{\circ} 14'$ .
----				A. D. Bache.	Sill. J., 1838 & 1842. E. Loomis.
13. 48				A. D. Bache and E. H. Courtenay.	C. S. Rpt., 1861, App. 22.
13. 52				E. Loomis.	Sill. J., Vol. XXXIX, 1840. The total intensities for Phila. = 13.41 for conversion of relative into absolute value.
13. 51				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----				A. D. Bache.	G. S. Rpt., 1862, App. 19.
13. 49	71. 98	4. 060	13. 12	J. Locke.	Sill. J., Vol. IV, 1847.
13. 48				Do.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 64				J. Renwick.	C. & G. S. Rpt., 1881, App. 9.
----				J. D. Graham.	Sill. J., Vol. IV, 1847.
----				J. Renwick.	C. & G. S. Rpt., 1881, App. 9.
13. 45				J. Locke.	Do.
----				Officer of corvette Nordsternen.	Letter of Prof. Hansteen, Oct. 15, 1854.
----				E. K. Kane and A. Sonntag.	Mag. Obsns. Arctic Seas. Smithsonian Cont's to Know. Wash., 1858.
13. 25				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 40				Do.	Do.
13. 27				Do.	Do.
13. 61				Do.	Do.
13. 31				A. H. Scott and E. Goodfellow.	Do.
13. 52				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 48				Do.	Do.
13. 426	71. 94	4. 05	13. 06	J. H. Lefroy.	Diary Mag. Sur. Canada. London, 1883. $\theta$ , H & F obs'd.
13. 47				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 57				J. Renwick and J. H. Lefroy.	C. & G. S. Rpt., 1881, App. 9.
13. 44				J. Locke.	Do.
13. 39	72. 20	4. 003	13. 10	J. M. Poole.	Do.
13. 51	72. 18	4. 060	13. 27	R. H. Fauntleroy.	Do.
13. 40	72. 18	4. 019	13. 13	E. Goodfellow and A. D. Bache.	Do.
13. 43	72. 13	4. 034	13. 15	E. Goodfellow and A. D. Bache.	Do.
13. 30	72. 29	3. 953	13. 00	J. Renwick.	Do.
12. 95	72. 04	(3. 904)	(12. 66)	Do.	Do.
13. 08	72. 15	(3. 916)	(12. 78)	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW YORK—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	$^{\circ}$ /	$^{\circ}$ /			$^{\circ}$ /	
East Hampton, on top of steep bank.	40 57.5	72 11.5	1875	Aug. 23, 24.	72 47.3	3.986
Port Chester, Sawpit's steamboat landing.	40 59.6	73 39.7	1844	Sept. 11.	72 53.4	----
Sag Harbor, Mulford's Hill.	40 59.9	72 17.4	1860	Sept. 4, 5.	73 20.9	3.903
Greenport.	41 06	72 21	1845	Aug. 19.	72 57.9	3.850
Carpenter's Point, Port Jervis.	41 21.4	74 41.7	1873	June 21, 23.	73 14.3	3.897
West Point, United States Military Academy.	41 23.5	73 57.3	1833	April.	73 25.8	----
Do.	41 23.5	73 57.3	1834	May, June, July.	73 37.2	----
West Point, United States Military Academy, rear of Courtenay's house.	41 23.5	73 57.3	1835	----	----	3.866
West Point, bank near steamboat landing.	41 24	73 58	1839	Sept.	73 27.4	----
West Point.	41 23.5	73 58	1840	Aug.	73 20.1	----
West Point, in Bartlett's garden.	41 24	73 58	1842	Oct. 19, 20.	73 31.5	3.886
West Point.	41 23.4	73 57	1843	July.	73 12.2	4.033
Cold Spring, on bluff west of railroad and near depot.	41 25.0	73 57.6	1855	Sept. 1.	73 54.8	3.790
Poughkeepsie.	41 42	73 56	1844	June 13.	73 57.7	3.733
Opposite Poughkeepsie.	41 42	73 57	1844	June 13.	74 12.3	3.728
Owego.	42 08	76 17	1841	Aug.	74 13.9	3.614
Belvedere.	42 13	78 06	1841	Aug.	74 09.5	3.669
Mayville, grounds of Public School.	42 16	79 40	1874	Aug. 4.	74 05.0	3.733
Ellicottsville.	42 18.1	78 44	1841	Aug.	74 17.8	3.726
Bath.	42 20.8	77 21	1841	Aug.	74 27.5	3.677
Bath, public park, opposite post-office.	42 20.8	77 21.3	1862	Aug. 11.	74 26.2	3.671
Bath, field belonging to Judge Runsey.	42 21	77 21	1874	July 24, 25.	74 15.5	3.724
Oxford, on hill about $\frac{3}{4}$ of a mile north of depot.	42 26.5	75 40.5	1874	June 4.	74 05.8	3.726
Ithaca, grounds of Cornell University.	42 27.5	76 33.0	1874	June 13.	74 14.7	3.664
Dunkirk.	42 29.3	79 23	1841	Aug.	74 17.2	3.621
Albany, side of hill between Orange and Pat- roon streets.	42 39	73 45	1833	April.	74 51.1	----
Albany.	42 39	73 45	1834	Aug.	74 40.1	----
Albany, yard of Franklin House, State street.	42 39	73 43	1835	----	----	3.578
Albany, northwest of the Capitol.	42 39	73 45	1839	Sept.	74 51.3	----
Albany, near Orphan Asylum, $\frac{1}{2}$ mile west of Capitol.	42 39.1	73 44.8	1841	Aug.	74 39.9	----
Albany.	42 39	73 45	1841	----	74 40.1	----
Albany, side of hill between Orange and Pat- roon streets.	42 39	73 45	1842	Oct. 21.	74 44.6	3.581
Albany.	42 39	73 45	1844	June 14.	74 40.2	3.582
Greenbush, opposite Albany.	42 38	73 44	1844	June 14.	74 43.1	3.578
Greenbush, near Second street.	42 37.5	73 44.3	1855	Aug. 31.	75 11.1	3.587
Albany.	42 40	73 45	1856	Sept.	74 56	3.575
Albany, Dudley Observatory.	42 39.8	73 45.0	1858	May 13-19.	74 55.6	3.586
Do.	42 39.8	73 45.1	1879	Oct. 21-24.	74 18.9	3.645

*intensities in the United States and adjacent regions.—Continued.*

NEW YORK—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	F .0		
13. 47	72. 23	4. 022	13. 18	J. M. Poole.	C. & G. S. Rpt., 1881, App. 9.
----	72. 20	----	----	J. Renwick.	Do.
13. 62	72. 55	4. 020	13. 41	C. A. Schott.	Do.
13. 14	72. 27	3. 917	12. 86	J. Renwick.	Do.
13. 51	72. 62	3. 944	13. 20	E. Smith.	Do.
----	72. 71	4. 009	13. 49	E. H. Courtenay and J. Henry.	Sill. J., Vol. XXXIV, 1838.
----				E. H. Courtenay.	Do.
13. 71				A. D. Bache and E. H. Courtenay.	Am. Phil. Soc., Vol. V, 1837, & C. S. Rpt., 1861, App. 22.
----				E. Loomis.	Sill. J., Vol. XXXIX, 1840.
----				J. D. Graham.	Sill. J., Vol. IV, 1847.
13. 702				J. H. Lefroy and Bartlett.	Diary Mag. Sur. Canada, London, 1883.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 68				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 51				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 70				Do.	Do.
----	73. 54	3. 656	12. 90	A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	73. 47	3. 711	13. 04	Do.	Do.
----	73. 49	3. 775	13. 28	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser.
----	73. 61	3. 768	13. 35	A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	73. 70	3. 754	13. 38	Do.	Do.
13. 68				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
----				F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser.
13. 60	73. 51	3. 768	13. 27	T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
13. 49	73. 65	3. 706	13. 17	Do.	Do.
----	73. 60	3. 663	12. 97	A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	74. 03	3. 673	13. 35	J. Henry and T. J. Cram.	Sill. J., Vol. XXXIV, 1838. E. Loomis.
----				A. D. Bache.	Do.
13. 53				A. D. Bache and E. H. Courtenay.	C. S. Rpt., 1861, App. 22.
----				E. Loomis.	Sill. J., 1840.
----				J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, 1843.
----				A. D. Bache.	Phil. Trans. R. S., 1846.
13. 610				J. H. Lefroy.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.
13. 55				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 58				Do.	Do.
14. 03				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
14. 00				K. Friesach.	K. K. Acad. d. Wiss. Vienna, Vol. XXIX, 1858.
13. 79				G. W. Dean.	C. & G. S. Rpt., 1881, App. 9.
13. 48				J. B. Baylor.	Do.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW YORK—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
	$^{\circ}$ /	$^{\circ}$ /			$^{\circ}$ /	
Sherburne, rear of Newton's barn.	42 41. 2	75 33. 0	1875	Sept. 2, 3, 4.	74 15. 1	3. 726
Troy.	42 43. 7	73 40. 7	1843	Aug.	74 47. 9	3. 575
Otsego,	42 46. 9	74 42. 2	1882	Aug. 16, 17.	73 55. 4	3. 673
Schenectady, south of village.	42 48	73 55	1839	Sept.	74 36. 1	----
Do.	42 48	73 57	1843	July.	74 54. 8	3. 502
Geneva.	42 53	77 02	1843	July.	74 33. 2	3. 635
Buffalo, east of the American House.	42 53	78 55	1839	Aug.	74 40. 8	----
Buffalo.	42 53	78 55	1844	June 23.	74 36. 5	3. 663
Buffalo, behind High School, Fourth and Dela- ware streets.	42 55	78 54	1845	Oct. 20.	74 37. 8	----
Buffalo.	42 53. 0	78 53. 0	1859	June 11.	74 47	3. 608
Buffalo, at Fort Porter.	42 55	78 54	1872	June 13, 14.	74 43	3. 644
Do.	42 55	78 54	1873	June 3-6.	74 29	3. 667
Fenner.	42 57. 4	75 44. 6	1882	Oct. 5, 6.	74 18. 4	3. 646
Howlett.	43 00. 0	76 17. 4	1883	Aug. 30, 31; Sept. 1, 3.	74 17. 5	3. 625
Syracuse, northeast of village.	43 01	76 09	1839	Sept.	74 50. 9	----
Syracuse.	43 00	76 09. 3	1843	July.	74 51. 2	3. 556
Niagara Falls, New York side east of town, near Cataract Hotel.	43 02	79 04	1841	Sept.	74 52. 4	----
Niagara Falls.	43 04	79 04	1843	Aug.	74 51. 0	3. 565
Niagara Falls.	43 03	79 04	1856	Sept. 12.	----	3. 600
Niagara Falls, in lot of Mr. Holley.	43 04	79 04	1874	July 31.	74 37. 7	3. 646
Clyde.	43 03. 1	76 51. 8	1883	Sept. 20, 21, 22.	74 31. 8	3. 580
Clinton, Hamilton College.	43 03. 2	75 24. 2	1874	Oct. 25.	74 37. 5	3. 635
Utica, northeast of village.	43 07	75 13	1839	Sept.	74 57. 2	----
Utica.	43 05	75 14	1843	July.	74 50. 3	3. 541
Do.	43 07	75 13	1844	June 16.	74 48. 8	3. 582
Rochester, corner Mill street, garden behind Mansion House.	43 10	77 41	1843	Mar. 14.	74 41. 0	----
Rochester.	43 07	77 39	1843	Aug.	74 43. 5	3. 560
Do.	43 08	77 41	1844	June 17.	74 38. 8	3. 615
Rochester College grounds.	43 08	77 40	1874	July 29.	74 38. 5	3. 632
Lockport.	43 11	78 46	1844	June 18.	74 44. 2	3. 599
Fort Niagara, near flagstaff.	43 15	79 04	1859	June 15.	74 51	3. 584
Charlotte, near light-house.	43 15	77 37	1859	June 18.	75 12	3. 561
Charlotte, Latty street, near Broadway.	43 15	77 37	1872	June 7-10.	74 58	3. 619
Charlotte, in rear of Methodist church.	43 15	77 37	1873	May 29, 30, 31.	74 50	3. 633
Loomis.	43 21. 3	76 17. 2	1882	Nov. 10, 11.	74 47. 7	3. 518

*intensities in the United States and adjacent regions.—Continued.*

NEW YORK—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1888.0}$	$H_{1888.0}$	$F_{1888.0}$		
	°				
13. 73	73. 83	3. 762	13. 51	J. M. Poole.	C. & G. S. Rpt., 1881, App. 9.
----	74. 11	3. 627	13. 25	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 264	73. 74	3. 682	13. 15	J. B. Baylor and C. O. Boutelle.	MS. in C. & G. S. Office.
----	74. 07	3. 554	12. 95	E. Loomis.	Sill. J., 1840.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	73. 96	3. 687	13. 34	Do.	Do.
----	73. 96	3. 715	13. 45	E. Loomis.	Sill. J., 1840.
13. 80				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 694	73. 96	3. 715	13. 45	J. H. Lefroy.	Diary Mag. Sur. Canada. Genl. Sir J. H. Lefroy, London, 1883.
13. 743	74. 14	3. 655	13. 37	W. P. Smith.	U. S. Lake Sur. Rpt., 1859.
13. 823				A. N. Lee.	U. S. Lake Sur. Rpt., 1873.
13. 707				Do.	Do.
13. 479	74. 14	3. 655	13. 37	J. B. Baylor and C. O. Boutelle.	MS. in C. & G. S. Office.
13. 389	74. 18	3. 630	13. 32	Do.	Do.
----	74. 15	3. 608	13. 21	E. Loomis.	Sill. J., Vol. XXXIX, 1840.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	74. 06	3. 690	13. 44	J. N. Nicolle.	Am. Phil. Soc., Vol. VIII, 1843.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
14. 32				K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858.
----	74. 43	3. 585	13. 36	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 421				J. B. Baylor and C. O. Boutelle.	MS. in C. & G. S. Office.
13. 71	74. 03	3. 676	13. 36	T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
----	74. 18	3. 617	13. 27	E. Loomis.	Sill. J., 1840.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 68				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 670	74. 01	3. 653	13. 26	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 66				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	74. 05	3. 657	13. 31	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.).
13. 68				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 716	74. 05	3. 706	13. 49	W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859.
13. 942	74. 31	3. 678	13. 60	Do.	Do.
13. 920				A. N. Lee.	U. S. Lake Sur. Gen'l C. B. Comstock, 1873.
13. 886				Do.	Do.
13. 414	74. 63	3. 526	13. 30	J. B. Baylor and C. O. Boutelle.	MS. in C. & G. S. Office.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
NEW YORK—Continued.

Name of station.	Latitude. φ.	West longi- tude	Year.	Month.	Dip. θ.	Horizontal force H.
Pen Mount.	43 22.8	75 15.6	1882	Aug. 21, 22.	74 31.4	3.606
Prospect.	43 25.9	73 45.4	1882	Aug. 7, 8, 9.	74 43.5	3.525
Oswego, west of village.	43 26	76 36	1839	Aug.	75 11.3	----
Oswego, Woodruff's garden, near Baptist church.	43 26	76 36	1841	Sept.	75 08.1	----
Oswego.	43 26	76 35	1843	Aug.	75 07.1	3.467
Pierrepoint Manor, about one-half mile south- west of village.	43 44.5	76 04.0	1874	Oct. 20.	75 25.1	3.470
Mannsville.	43 42.9	76 03.2	1884	June 6, 7, 9.	----	3.468
Sackett's Harbor, near barracks.	43 57	76 07	1859	June 22.	75 44	3.403
Sackett's Harbor, at barracks.	43 57	76 07	1872	June 5.	75 27	3.482
Do.	43 57	76 07	1873	May 26, 27.	75 24	3.471
Potsdam, about one-half mile southwest of depot.	44 37.0	75 00.0	1874	Oct. 15.	76 03.3	3.268
Rouse's Point.	45 00	73 22	1845	----	76 40.7	----
Rouse's Point, near Major Graham's monument.	45 00.4	73 21.2	1879	Oct. 1.	76 18.2	3.270

## NORTH CAROLINA.

Fort Johnson, Smithville.	33 55.0	78 00.9	1859	May 3-7.	66 17.1	5.260
Fort Johnson, near flag-staff.	33 55.0	78 00.9	1874	Dec. 27-30.	66 00.6	5.297
Wilmington, near Dr. Drune's house.	34 14.0	77 56.6	1854	June 3, 5.	66 47.2	5.195
Beaufort.	34 43	76 40	1880	Jan. 14, 15.	66 49.8	5.055
Portsmouth Island, Northeast Base.	35 04.0	76 03.2	1871	Apr. 1-5.	67 13.6	5.006
New Berne, National Cemetery.	35 07.4	77 03.3	1874	Dec. 21-24.	67 30.6	4.959
Charlotte, corner Church and Sixth streets.	35 14	80 46	1873	Aug. 1.	67 07.5	5.089
Asheville.	35 36	82 30	1833	Sept.	67 25	----
Asheville, grounds of Eagle Hotel.	35 35	82 30	1873	Aug. 7.	67 26.7	5.078
Salisbury.	35 40.4	80 20	1873	July 30.	67 46.0	5.021
Raleigh, grounds of Capitol.	35 46.8	78 38.1	1854	Jan. 7-16.	68 11.6	4.963
Morganton, opposite Episcopal Church.	35 47.4	81 30	1873	Aug. 5.	67 15.3	5.067
Bodie's Island, near Midgett's house.	35 47.5	75 32.0	1846	Dec. 25-28.	68 18.1	4.755
Warm Spring.	35 50	82 48	1833	Sept.	67 39	----
Sand Island.	35 50.4	75 40.1	1876	Jan. 22; Feb. 7.	68 05.4	4.893
Greensboro', Gaston street, above Green.	36 03.5	79 40	1873	July 28.	68 35.3	4.901
Shellbank.	36 03.6	75 44.5	1847	Mar. 26; Apr. 9.	68 37.8	4.714
Stevenson's Point.	36 06.3	76 11.4	1847	Jan. 30; Feb. 15.	68 54.5	4.660

*intensities in the United States and adjacent regions.—Continued.*

NEW YORK—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 514	74. 34	3. 614	13. 39	J. B. Baylor & C. O. Boutelle.	MS. in C. & G. S. Office.
13. 380	74. 54	3. 533	13. 25	Do.	Do.
----	74. 46	3. 519	13. 14	E. Loomis.	Sill. J., Vol. XXXIX, 1846. The total intensity for Phila. = 13.41 for conversion of relative into absolute value.
----				J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, 1843.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 78	74. 83	3. 490	13. 34	T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
----				J. B. Boutelle.	MS. in C. & G. S. Office.
13. 809	74. 83	3. 525	13. 47	W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859.
13. 847				A. N. Lee.	U. S. Lake Sur., Gen'l C. B. Comstock, 1873.
13. 770				Do.	Do.
13. 56	75. 47	3. 309	13. 19	T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
----	75. 95	3. 290	13. 55	J. D. Graham.	Sill. J., Vol. IV, 1847.
13. 81				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 19.

## NORTH CAROLINA.

13. 08	65. 80	5. 310	12. 95	G. W. Dean.	C. & G. S. Rpt., 1881, App. 9.
13. 03				J. B. Baylor.	Do.
13. 18	66. 40	5. 237	13. 08	G. W. Dean.	Do.
12. 85	66. 66	5. 065	12. 78	J. B. Baylor.	Do.
12. 93	66. 89	5. 035	12. 83	A. T. Mosman.	Do.
12. 96	67. 22	4. 979	12. 86	J. B. Baylor.	Do.
----	66. 82	5. 112	12. 99	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	67. 06	5. 101	13. 09	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
----				F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	67. 46	5. 044	13. 16	Do.	Do.
13. 36	67. 80	5. 00	13. 23	G. W. Dean.	C. & G. S. Rpt., 1881, App. 9.
----	66. 95	5. 090	13. 00	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
12. 86	67. 96	4. 79	12. 77	C. O. Boutelle.	C. & G. S. Rpt., 1881, App. 9.
----	67. 23	----	----	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
13. 11	67. 82	4. 910	13. 01	E. Smith.	C. & G. S. Rpt., 1881, App. 9.
----	68. 28	4. 924	13. 31	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
12. 94	68. 29	4. 75	12. 84	C. O. Boutelle and G. Davidson.	C. & G. S. Rpt., 1881, App. 9.
12. 95	68. 57	4. 69	12. 84	C. O. Boutelle.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

OHIO.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Cincinnati.	° / 39 06	° / 84 26	1838	Mar. 20.	° / 70 28. 1	----
Do.	39 06	84 27	1838	----	70 46	----
Do.	39 06	84 27	1840 {	Aug. 18. Sept. 24.	70 27. 4 70 29. 2	} ----
Do.	39 06	84 27	1841	May 8.	70 26. 2	----
Cincinnati, Longworth's Garden, east side of city.	39 06	84 27	1841	Oct.	70 27. 7	----
Cincinnati.	39 06	84 27	1842	Mar. 31.	70 25. 4	----
Do.	39 06	84 27	1843	Aug. 21.	70 25. 5	----
Do.	39 06	84 27	1844 {	Mar. 21. July 4.	70 28 70 25	} 4. 548
Do.	39 06	84 27	1845	Apr. 23.	70 26	4. 548
Cincinnati, Longworth's Garden.	39 06	84 27	1849	June 5.	70 28. 8	----
Cincinnati Observatory, on Mount Lookout.	39 08. 6	84 25. 4	1880	Nov. 29, 30.	70 24. 7	4. 488
Athens, west of College buildings.	39 19. 8	82 02	1880	Dec. 3, 4.	70 58. 7	4. 390
Mason.	39 22	84 13	1840	Aug. 25.	70 54. 2	4. 442
Hamilton.	39 23	84 32	1840	Aug. 20.	70 58	4. 448
Marietta.	39 25	81 28	1845	----	71 22. 3	----
Lebanon.	39 26	84 06	1840	Aug. 24.	71 02. 7	4. 419
Oxford.	39 30	84 38	1845	----	71 10. 0	----
Carrollton.	39 38	84 09	1840	----	71 10. 0	----
Dayton.	39 45	84 09	1838	Mar. 26.	71 22. 7	4. 369
Do.	39 44	84 09	1840	Aug. 21.	71 22. 0	4. 339
Springfield.	39 54	83 50	1838	Mar. 29.	71 27. 4	4. 329
Columbus.	39 57	83 01	1838	Apr. 2.	71 04. 9	4. 408
Columbus, east of new State House yard.	39 57. 7	82 59. 5	1841	Oct.	71 03. 4	----
Columbus.	39 57	83 01	1845	----	71 04. 3	----
Columbus, Capitol Square.	39 57. 7	82 59. 7	1871	Oct. 3-9.	71 09. 8	4. 369
Columbus, grounds of Blind Asylum.	39 57	82 59	1874	Aug. 19.	70 59. 7	4. 359
Hebron, north of Stage House.	39 59	82 29	1841	Oct.	71 10. 1	----
Urbana.	40 03	83 42	1838	Mar. 30.	71 39. 7	4. 347
Piqua.	40 06	84 13	1840	Aug. 22.	71 35. 8	4. 301
Frazeyshurg, near canal lock No. 16.	40 09	82 08	1841	Oct.	71 48. 7	----
Tuscarawas, field of Blinkensdorfer.	40 24. 2	81 50	1874	Aug. 17.	72 08. 5	4. 146
Steubenville.	40 25	80 39	1840	Aug.	72 32. 8	3. 947
St. Mary's.	40 32	84 19	1845	----	72 00. 3	----

*intensities in the United States and adjacent regions.—Continued.*

## OHIO.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	o			J. Locke.	Am. Phil. Soc., Phila., 1846, Art. XI; Dr. J. Locke's paper for 1884.
----				Do.	Sill. J., Vol. XXXIV, 1838. (Loomis collection.)
----				Do.	Sill. J., 1840, E. Loomis, and Am. Phil. Soc., Vol. VII, 1840, and 1846, Art. XI.
----				Do.	Am. Phil. Soc., Vol. IX, 1846.
----	69. 9	4. 58	13. 33	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----				J. Locke.	Sill. J., Vol. IV, 1847.
----				Do.	Am. Phil. Soc., 1846, Art. XI.
13. 59				Do.	Am. Phil. Soc., 1846, Art. XI, and for H. and F., Phil. Trans. R. S., 1846; E. Sabine.
----				Do.	Smithsonian Cont's to Know., Vol. 3, 1852.
13. 548				J. H. Lefroy.	Diary Mag. Sur., Canada, London, 1883.
13. 39	70. 19	4. 496	13. 27	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 47	70. 77	4. 405	13. 38	Do.	Do.
13. 58	70. 38	4. 48	13. 35	J. Locke.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13. 64	70. 45	4. 49	15. 42	Do.	Do.
13. 62	70. 86	4. 41	13. 46	Do.	Phil. Trans. R. S., 1846.
13. 60	70. 51	4. 46	13. 37	Do.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13. 66	70. 66	4. 47	13. 50	Do.	Phil. Trans. R. S., 1846.
13. 62	70. 64	4. 44	13. 39	Do.	Do.
13. 69	70. 82	4. 39	13. 36	Do.	Sill. J., 1838, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13. 58				Do.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13. 61	70. 91	4. 36	13. 34	Do.	Do.
13. 60				Do.	Sill. J., 1838, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI.
----	70. 56	4. 422	13. 29	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----				J. Locke.	Phil. Trans. R. S., 1846.
13. 53				A. T. Mosman.	C. & G. S. Rpt., 1881, App. 9.
----				F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	70. 65	----	----	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis.
13. 81	71. 11	4. 38	13. 54	J. Locke.	Sill. J., 1838, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13. 62	71. 08	4. 34	13. 39	Do.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
----	71. 29	----	----	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis.
----	71. 69	4. 188	13. 33	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	72. 03	(3. 99)	(12. 93)	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 66	71. 49	4. 28	13. 47	J. Locke.	Phil. Trans. R. S., 1846.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

OHIO—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
	° /	° /			° /	
Dover, near canal lock, 2 miles north of town.	40 33	81 30	1841	Oct.	72 19.2	----
Wellsville, Ohio River.	40 38	80 44	1844	June 26.	72 35.3	4.060
Forest, woods south of town.	40 50	83 28	1874	Aug. 21.	72 20.7	4.108
Fulton, near canal lock.	40 55	81 38	1841	Oct.	72 38.9	----
Clinton, near canal lock.	40 58	81 40	1841	Oct.	72 44.0	----
Tallmadge.	41 06	81 27	1841	{ Apr. Oct.	{ 72 55.2 72 51.5	{ ----
Hudson, Western Reserve College.	41 15	81 26.0	1838	Sept.	72 48.2	----
Do.	41 15	81 26.0	1839	Apr., May, Aug., Oct.	72 47.3	----
Do.	41 15	81 26.0	1840	{ ---- Jan. to Aug.	{ 72 53.9 72 49.5	{ 4.039
Do.	41 15	81 26.0	1841	May–Nov.	72 48.3	----
Windham.	41 15	81 03	1840	----	73 03.4	----
Shakersville.	41 15	81 13	1840	----	72 56.6	----
Streetsboro'.	41 15	81 20	1840	----	72 53.0	----
Warren.	41 16	80 49	1840	----	73 00.7	----
Do.	41 17	80 50	1841	Aug.	72 59.9	3.978
Do.	41 16	80 54	1844	June 25.	72 55.9	4.005
Hartford.	41 19	80 34	1840	----	72 59.8	----
Bazetta.	41 20	80 45	1840	----	72 59.7	----
Aurora.	41 20	81 20	1840	----	72 55.5	----
Twinsburgh.	41 20	81 26	1840	----	72 51.3	----
Bedford.	41 24	81 32	1840	----	72 58.1	----
Huron.	41 26	82 27	1843	June 6.	73 00.0	4.019
Sandusky, south of village.	41 29	82 43	1839	May.	72 57.8	----
Kinsman.	41 30	80 34	1840	----	73 08.1	----
Brooklyn, 1 mile west of city.	41 30	81 43	1841	Apr.	73 16.3	----
Cleveland, front of American Hotel.	41 30	81 42	1839	May.	73 26.0	----
Cleveland.	41 30	81 42	1840	----	73 14.1	----
Do.	41 30	81 42	1841	Aug.	73 04.3	----
Cleveland, front of hill, near landing.	41 30.3	81 42	1842	Nov. 3.	73 03.8	----
Cleveland.	41 30	81 42	1843	Aug. 4.	73 08	4.005
Cleveland, near Marine Hospital.	41 30.0	81 40.0	1859	July 4.	73 20	3.956
Cleveland.	41 30.5	81 41.5	1871	Nov. 6–14.	73 09.3	4.000
Cleveland, near Marine Hospital.	41 30	81 40	1872	June 17, 18.	73 07	4.017
Do.	41 30	81 40	1873	June 16, 17.	73 08	3.996
Cleveland.	41 30.5	81 41.5	1880	July 9, 12.	73 02.4	3.996
Maumee, north of village.	41 34	83 37	1839	May.	72 49.1	----
Toledo, west of village.	41 41	83 32	1839	May.	73 06.1	----
Ashtabula, close to Lake.	41 52	80 52	1844	June 24.	73 25.0	3.911
Ashtabula Landing.	41 54	80 47	1841	Aug.	72 23.5	3.838

*intensities in the United States and adjacent regions.—Continued.*

OHIO—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	0				
13. 57	71. 80 72. 08	----	13. 38	E. Loomis. J. Locke.	Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis. Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
----	71. 89	4. 150	13. 35	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	72. 13	----	----	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis.
----	72. 21	----	----	Do.	Do.
----	72. 37	----	----	Do.	Do.
----				Do.	Sill. J., 1840.
----				Do.	Do.
13. 55	72. 28	4. 08	13. 41	Do.	Sill. J., 1840, and Trans. Am. Phil. Soc., Vol. VIII, 1843.
----				Do.	Am. Phil. Soc., Vol. VIII, 1843.
----	72. 53	----	----	Do.	Phil. Trans. R. S., 1846.
----	72. 41	----	----	Do.	Do.
----	72. 35	----	----	Do.	Do.
----				Do.	Do.
13. 65	72. 46	4. 04	13. 42	A. D. Bache. J. Locke.	C. S. Rpt., 1862, App. 19. Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	72. 47	----	----	E. Loomis.	Phil. Trans. R. S., 1846.
----	72. 47	----	----	Do.	Do.
----	72. 40	----	----	Do.	Do.
----	72. 33	----	----	Do.	Do.
----	72. 45	----	----	Do.	Do.
13. 75	72. 49	4. 07	13. 54	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	72. 42	----	----	E. Loomis.	Sill. J., 1840.
----	72. 61	----	----	Do.	Phil. Trans. R. S., 1846.
----				Do.	Am. Phil. Soc., Vol. VIII, 1843. Prof. E. Loomis.
----				Do.	Sill. J., 1840.
----				Do.	Phil. Trans. R. S., 1846.
13. 666				Do.	Am. Phil. Soc., Vol. VIII, 1843.
13. 80	72. 74	4. 046	13. 64	C. Younghusband. J. Locke.	Diary Mag. Sur. Canada. London, 1883, Sir. J. H. Lefroy. Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844, and Sill. J., Vol. IV, 1847.
13. 794				W. P. Smith.	U. S. Lake Survey Rpt., 1859.
13. 80				E. Goodfellow.	C. & G. S. Rpt., 1881, App. 9.
13. 833				A. N. Lee.	U. S. Lake Survey MS., 1873.
13. 773				Do.	Do.
13. 70				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----	72. 28	----	----	E. Loomis.	Sill. J., 1840.
----	72. 56	----	----	Do.	Do.
13. 71	72. 91	3. 97	13. 51	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	(71. 88)	3. 88	(12. 49)	A. D. Bache.	C. S. Rpt., 1862, App. 19.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

## OREGON.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Jacksonville, grounds of public school.	42 18	122 58	1881	July 16, 17.	66 03.2	5.021
Canyonville, Pine street, between Second and Third.	42 54	123 18	1881	July 19.	65 57.9	----
Oakland, academy grounds.	43 26	123 18	1881	July 22.	66 59.4	----
Eugene, grounds of State University.	44 03	123 00	1881	July 25.	67 51.0	4.796
River Santiam.	44 35	122 27	1830	Aug.	68 28	4.647
Albany, College Square.	44 39	123 02	1881	July 27, 28.	68 08.5	4.715
Salem, near State Capitol and court-house.	44 56.5	122 58	1881	July 30, 31.	68 13.3	4.702
River Multnomah.	45 15	122 47	1830	Aug.	68 57	4.514
Portland, west of Clarendon Hotel.	45 31.5	122 40.5	1880	May 1.	69 35.6	4.414
Portland, court-house block.	45 31.5	122 41.5	1881	Aug. 5, 6.	69 24.2	4.488
Dalles, three-mile camp.	45 35	120 49	1860	May 21.	69 41.8	----
Three-Mile Creek, top of north bank.	45 39	120 58	1881	Oct. 13, 14.	----	4.473
Blalock, near Griffin's house and railroad station.	45 44	120 15	1881	Oct. 8.	----	4.495
Saint Helen's.	45 52.3	122 48.1	1881	Aug. 15.	70 54.1	4.350
Umatilla, on First street, near D.	45 57	119 20	1881	Oct. 5.	70 10.2	4.421
Point George, Columbia River.	46 11	123 40	1830	Dec.	69 16.8	----
Astoria, school-house block.	46 11.5	123 50	1881	Aug. 10, 11.	69 13.4	4.508

## PENNSYLVANIA.

Near Mercersburg.	39 47	77 56	1840	Aug.	71 47.3	4.188
Chambersburg.	39 55	77 40	1842	Apr. 9.	71 57.1	4.197
York, west bank of river.	39 58	76 44	1874	July 13.	71 54.5	4.182
Philadelphia, yard of Bache's house, Chestnut street.	39 58	75 10	1834	July.	72 00.2	----
Do.	39 58	75 10	1835	----	----	4.195
Do.	39 58	75 10	1836	Sept.	----	4.159
Philadelphia, Rittenhouse Square.	39 58	75 10	1838	July.	71 43.9	----
Philadelphia, front of Dr. Bache's house.	39 58	75 10	1839	Sept.	72 07.1	4.149
Philadelphia.	39 58	75 10	1840	July, Sept., Oct.	71 53.0	----
Philadelphia, Girard College.	39 58.4	75 10.2	1841	Mar. 30.	72 00.2	4.179
				Mar. 31.	72 01.3	4.175
				Apr. 26.	71 59.0	4.171
				Apr. 26; July 20; Oct. 9; Nov. 1.	71 58.7	4.176
Do.	39 58.4	75 10.2	1841	June.	71 54.5	----
Do.	39 58.4	75 10.2	1842	May 15.	72 01	4.178
Do.	39 58.4	75 10.2	1842	Oct. 6.	71 59.0	4.176

*intensities in the United States and adjacent regions.—Continued.*

## OREGON.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$H_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
12. 37	66. 05	5. 004	12. 33	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
----	65. 96	----	----	Do.	Do.
----	66. 98	----	----	Do.	Do.
12. 72	67. 84	4. 779	12. 67	Do.	Do.
12. 66	----	4. 650	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, London, 1838, & Phil. Trans. R. S., 1872, Cont. XIII.
12. 66	68. 13	4. 698	12. 61	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
12. 67	68. 21	4. 685	12. 62	Do.	Do.
12. 57	----	4. 517	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, London, 1838, & Phil. Trans. R. S., 1872, Cont. XIII.
12. 66	} 69. 47	4. 444	12. 67	W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
12. 76			----	J. S. Lawson.	Do.
13. 151	69. 7	4. 448	12. 82	R. W. Haig.	B. S. Phil. Trans. R. S., 1864.
----	----	4. 456	----	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
----	----	4. 478	----	Do.	Do.
13. 29	70. 89	4. 333	13. 24	Do.	Do.
13. 03	70. 15	4. 405	12. 97	Do.	Do.
----	} 69. 20	4. 491	12. 65	D. Douglas.	Rpt. Brit. Asso., Vol. VI, London, 1838.
12. 71			----	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.

## PENNSYLVANIA.

----	71. 27	4. 230	13. 17	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 55	71. 44	4. 247	13. 34	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----	71. 46	4. 224	13. 28	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser.
----	}			A. D. Bache and E. H. Courtenay.	Sill. J., Vol. XXXIV, 1838. E. Loomis.
13. 58				Do.	Am. Phil. Soc., Vol. V, 1837, and C. S. Rpt., 1861, App. 22.
13. 46				A. D. Bache.	C. S. Rpt., 1861, App. 22.
----				Do.	Sill. J., Vol. XXXIX, 1840. E. Loomis.
13. 41	}			E. Loomis.	Phil. Trans. R. S., 1846, E. Sabine, & C. S. Rpt., 1861, App. 22.
----				A. D. Bache.	Sill. J., Vol. XLII, 1842, & C. S. Rpt., 1864, App. 18.
13. 52				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 55				A. D. Bache.	C. S. Rpt., 1864, App. 18.
13. 48	}			J. D. Graham and A. D. Bache.	Phil. Trans. R. S., 1846. Sir E. Sabine.
13. 50				J. Locke.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
----				J. H. Lefroy.	Diary Mag. Sur. Canada, London, 1883. H. & F. obs'd.
13. 577				----	----
----	71. 38	4. 230	13. 25	----	----

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
PENNSYLVANIA—Continued.

Name of station.	Latitude <i>φ.</i>	West longi- tude <i>λ.</i>	Year.	Month.	Dip <i>θ.</i>	Horizontal force <i>H.</i>
Philadelphia, Girard College.	39 58	75 10	1842	----	72 01.8	----
Do.	39 58.4	75 10.2	1842	Jan. to Dec.	72 00.1	4. 174
Do.	39 58.4	75 10.2	1843	Apr. to Dec.	71 58.2	4. 172
Do.	39 58.4	75 10.2	1844	Apr. 19.	71 59.2	4. 158
Philadelphia, Rittenhouse Square.	39 58	75 10	1844	May.	72 09.2	----
Philadelphia, Girard College.	39 58.4	75 10.2	1844	Jan. to July.	71 57.6	4. 169
Do.	39 58.4	75 10.2	1845	Jan. to June.	----	4. 167
Do.	39 58.4	75 10.2	1846	May 23.	72 01.0	4. 143
Philadelphia, Girard College, northeast station.	39 58.4	75 10.2	1855	Sept. 5.	72 17.7	4. 211
Do.	39 58.4	75 10.2	1862	Aug 15, 16.	72 05.8	4. 124
Philadelphia, Navy-Yard.	39 56	75 07	1865	Oct. 24.	----	4. 148
Philadelphia, Girard College.	39 58.4	75 10.2	1872	Oct. 19–22.	72 15.4	4. 161
Do.	39 58.3	75 10.3	1877	Oct. 2–6.	71 41.3	4. 211
Philadelphia, Exhibition Laboratory.	39 57.1	75 11.0	1884	Aug. 29–31.	71 30.7	4. 196
Philadelphia, Girard College.	39 58.3	75 10.3	1884	Sept. 3–11.	71 27.4	4. 232
Yard, primary triangulation station.	39 58.3	75 23.1	1854	Oct. 28; Nov. 3.	73 01.2	3. 876
Near Brownsville.	39 59.5	79 47.8	1840	Aug.	71 53.5	4. 207
Johnson's tavern, near Brownsville.	39 59.5	79 48.1	1862	July 31.	71 57.0	4. 173
Bristol.	40 05.6	74 51.5	1842	May 13.	72 25	4. 046
Bristol, Vanuxem.	40 06.7	74 53.0	1846	June 10, 11, 12.	72 22.3	4. 068
Greenfield, near Johnston's tavern.	40 06	79 52	1874	Aug. 13, 14.	71 58.9	4. 185
Cumberland.	40 15	76 50	1844	----	71 36.0	----
Harrisburg.	40 16	76 53	1840	July.	72 20.5	4. 078
Harrisburg, grounds of State House.	40 15.8	76 52.9	1862	July 28, 29.	72 31.6	4. 048
Do.	40 15.8	76 52.9	1877	Sept. 27.	72 20.5	4. 123
Doylestown.	40 18	75 10	1841	July.	72 23.1	4. 189
Reading.	40 19	75 55	1840	July.	72 32.2	4. 000
Duncan Island.	40 25	77 01	1840	July.	72 35.0	3. 963
Alleghany Summit.	40 27	78 10	1845	May 5.	72 27.1	4. 105
Pittsburg.	40 27	80 00	1819	May 1.	78 12(?)	----
Pittsburg, opposite side of Allegheny River.	40 28	80 00	1839	Sept.	72 38.9	----
Pittsburg, vicinity of.	40 28	79 59.5	1840	Aug.	72 32.1	4. 049
Pittsburg.	40 28	80 00	1841	Mar. 22.	72 43.5	4. 059
Do.	40 28	80 00	1842	Apr. 7.	72 43.2	4. 056
Do.	40 27	80 00	1845	May 3.	72 46.7	4. 034
Allegheny, grounds of Observatory.	40 27.6	80 00.8	1878	Sept. 5.	72 07.5	4. 1294
Armagh.	40 29	79 04	1840	Aug.	72 18.7	4. 038
Huntingdon.	40 30.5	78 02	1840	July.	72 17.8	4. 109

*intensities in the United States and adjacent regions.—Continued.*

## PENNSYLVANIA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
-----	°			J. D. Graham.	Sill. J., Vol. IV, 1847.
13. 51				A. D. Bache.	C. S. Rpt., 1864, App. 18.
13. 48				Do.	Do.
13. 45				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
-----				J. D. Graham.	Phil. Trans. R. S., 1846.
13. 46				A. D. Bache.	C. S. Rpt., 1864, App. 18.
-----				Do.	Do.
13. 42				J. Locke.	C. & G. S. Rpt., 1881, App. 9.
13. 85				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9 (recomputed).
13. 42				Do.	C. & G. S. Rpt., 1881, App. 9.
-----				W. Harkness.	Smithsonian Cont's to Know., No. 230, Wash., 1873, Cruise of the Monadnock.
13. 65				A. H. Scott and E. Good-fellow.	C. & G. S. Rpt., 1881, App. 9.
13. 40				J. B. Baylor.	Do.
13. 233				E. Smith.	MS. in C. & G. S. Office.
13. 307				Do.	Do.
13. 27	72. 44	3. 961	13. 13	J. E. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
-----	} 71. 36	4. 251	13. 30 {	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 47				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 40	} 71. 88	4. 115	13. 23 {	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 43				Do.	C. & G. S. Rpt., 1881, App. 9.
-----	71. 53	4. 227	13. 34	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 54	71. 10	4. 332	13. 37	J. Locke.	Phil. Trans. R. S., 1846.
-----	} 71. 92	4. 133	13. 32 {	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 48				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 59	} 71. 86	4. 235	13. 60	E. Smith and J. B. Baylor.	Do.
-----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
-----	72. 01	4. 042	13. 09	Do.	Do.
-----	72. 05	4. 005	13. 00	Do.	Do.
13. 62	71. 94	4. 167	13. 44	J. Locke.	Phil. Trans. R. S. 1846. Smithsonian Cont's to Know., Vol. III, 1852.
-----				S. H. Long.	Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823. Dip probably 73° 12'. (Loomis.)
-----				E. Loomis.	Sill. J., 1840.
-----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 67	72. 11	4. 110	13. 38	J. Locke.	Sill. J., Vol. IV, 1847, and Trans. Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
13. 66				Do.	Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844.
-----				Do.	Smithsonian Cont's to Know., Vol. III, 1852.
13. 453				T. E. Thorpe.	Proc. R. S., No. 200, 1880.
-----	71. 80	4. 080	13. 06	A. D. Bache.	C. S. Rpt., 1862, App. 19.
-----	71. 77	4. 151	13. 27	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
PENNSYLVANIA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Altoona.	40 30.6	78 25	1874	July 16.	72 21.7	4.120
Lewistown.	40 35.5	77 35.5	1840	July.	72 30.0	3.984
Economy.	40 37	80 16	1840	Aug.	72 35.0	4.008
Bethlehem, Lehigh College Observatory.	40 37.5	75 18.0	1874	June 20.	73 38.9	3.839
Easton.	40 42	75 15	1841	July.	72 39.0	4.121
Beaver, bank building, near Beaver Bridge.	40 43.7	80 18	1839	Oct.	72 40.3	----
Beaver, near the river.	40 43.5	80 16	1874	Aug. 11.	72 31.5	4.056
Bellefonte.	40 55	77 49	1841	July.	72 42.3	4.069
Curwinstown.	40 57.5	78 36	1841	Aug.	72 49.7	3.999
Bushkill.	41 07	75 00	1841	Aug.	73 31.4	3.866
Mercer.	41 13.8	80 16	1841	Aug.	72 57.2	4.000
Wilkesbarre.	41 14	75 58	1841	July.	73 10.0	3.961
Williamsport.	41 14	77 02	1841	July.	72 54.4	3.983
Williamsport, near old Academy building.	41 14.0	77 02.4	1862	Aug. 13.	72 51.0	3.958
Williamsport, field west of Woodward's house.	41 15	77 03	1874	July 18, 20.	72 47.5	4.003
Berlin Tavern.	41 16	79 36	1841	Aug.	72 52.8	4.026
Sharpsville.	41 17	80 27	1874	Aug. 6.	72 50.7	4.002
Milford.	41 19	74 51.5	1841	Aug.	73 47.6	3.769
Silver Lake.	41 56.6	76 02	1841	Aug. 23.	----	3.782
Erie, near French and Seventh streets.	42 07.5	80 06.3	1841	Aug.	73 46.6	3.792
Erie, Presque Isle Harbor.	42 09.8	80 05.3	1859	June 7.	73 56	3.784
Erie, same place as in 1841, near school-house.	42 07.5	80 06.3	1862	Aug. 6, 7.	73 52.3	3.761
Erie, on Peninsula, near beacon light.	42 08.2	80 05.3	1873	June 11, 12.	73 46	3.829
RHODE ISLAND.						
Point Judith.	41 21.6	71 28.9	1847	Sept. 6-14.	73 45.1	3.788
Newport.	41 29	71 19	1835	----	----	3.775
Coaster's (Harbor) Island, near Newport.	41 30.5	71 19.7	1885	Apr. 21, 22, 23.	73 03.4	3.856
McSparran, summit of hill.	41 29.7	71 27.4	1844	July 13-24.	73 47.6	----
Spencer.	41 40.7	71 29.7	1844	July, Aug., Sept.	75 07.1	----
Providence, north of Brown University.	41 50.3	71 24	1834	Aug.	74 02.8	----
Do.	41 50.3	71 23.9	1835	----	----	3.770
Providence, steamboat landing.	41 49	71 25	1839	Sept.	73 59.6	3.726
Providence.	41 50	71 25	1841	----	74 02.8	----
Providence, near steamboat landing.	41 49	71 25	1842	Sept. 28.	74 00.0	3.715
Providence, east of Brown University.	41 50.2	71 23.7	1855	Aug. 20.	74 15.9	3.590
Do.	41 50.2	71 23.7	1885	Apr. 11, 13, 14.	73 10.5	3.814
Providence.	41 50	71 24	1884	June 20.	73 16.6	3.7685
Beaconpole.	41 59.7	71 27.0	1844	Nov. 8-19.	74 21.9	----

*intensities in the United States and adjacent regions.—Continued.*

PENNSYLVANIA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1886.0}$	$F_{1886.0}$		
----	71.91	4.162	13.40	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	71.98	4.026	13.01	A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	72.06	4.050	13.15	Do.	Do.
13.64	73.20	3.881	13.43	T. C. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
----	72.13	4.167	13.58	A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	72.11	4.098	13.34	E. Loomis.	Sill. J., 1840.
----				F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	72.18	4.115	13.45	A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	72.31	4.045	13.31	Do.	Do.
----	73.00	3.912	13.38	Do.	Do.
----	72.43	4.046	13.40	Do.	Do.
----	72.65	4.007	13.44	Do.	Do.
----	72.30	4.037	13.28	Do.	Do.
13.42				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
----	72.36	4.072	13.44	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	72.39	4.044	13.37	F. E. Hilgard and W. Diehl.	C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser.
----	73.27	3.815	13.25	A. D. Bache.	C. S. Rpt., 1862, App. 19.
----	----	3.828	----	Do.	Do.
----	73.29	3.856	13.41	Do.	Do.
13.661				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, 1859.
13.54				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13.697	73.49	----	----	A. N. Lee.	U. S. Lake Sur., Gen. C. B. Comstock, 1873.
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## RHODE ISLAND.

13.54	72.85	3.871	13.13	R. H. Fauntleroy.	C. & G. S. Rpt., 1881, App. 9.
----	----	3.785	----	A. D. Bache and E. H. Courtenay.	Am. Phil. Soc., Phila., Vol. V, 1837; C. S. Rpt., 1861, App. 22. H at Phila. = 4.195 used as unit. (Schott.)
13.23	73.09	3.854	13.25	J. B. Baylor.	MS. in U. S. C. & G. S. Office.
----	72.92	----	----	A. D. Bache and T. J. Lee.	C. & G. S. Rpt., 1881, App. 9.
----	74.25	----	----	T. J. Lee.	Do.
----	73.19	3.768	13.03	A. D. Bache.	Sill. J., 1838, E. Loomis.
13.72				A. D. Bache and E. H. Courtenay.	Am. Phil. Soc., Phila., Vol. V, 1837; C. S. Rpt., 1861, App. 22. H at Phila. = 4.195 used as unit. (Schott.)
13.41				E. Loomis.	Sill. J., 1840, & C. S. Rpt., 1861, App. 22.
----	73.49	----	----	A. D. Bache.	Phil. Trans. R. S., 1846.
13.477				J. H. Lefroy.	Diary Mag. Sur. Canada, London, 1883.
13.24				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13.21				J. B. Baylor.	MS. in U. S. C. & G. S. Office.
13.151	73.49	----	----	O. T. Sherman.	Rpt. Board of Managers Yale College Obser'y, 1884-'85.
----				T. J. Lee.	C. & G. S. Rpt., 1881, App. 9.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
SOUTH CAROLINA.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Graham, near bank of Scull Creek.	32 13.3	80 45.5	1870	Mar., Apr.	63 28.1	5.663
Port Royal, Saint Helena Island.	32 17.7	80 38.5	1859	Jan. 28, 29, 30.	64 07.5	----
Beaufort, corner Wilmington and Bay streets.	32 26.0	80 40.5	1874	Apr. 16-25.	----	5.603
Do.	32 26.0	80 40.5	1875	Apr. 9, 10, 12.	----	5.586
East Base, Edisto Island.	32 33.3	80 13.5	1850	Apr. 5-11.	64 04.1	5.623
Charleston.	32 47	79 56	1833	Jan.	----	5.920
Breach Inlet, near Charleston.	32 46.3	79 48.9	1849	Apr. 6-25.	64 31.9	5.547
Fort Marshall, near Breach Inlet.	32 46.4	79 48.8	1874	May 27, 28.	----	5.530
Breach Inlet, near Truesdale's house.	32 46.4	79 48.8	1880	Jan. 21, 22.	64 13.7	5.530
Allston, near Georgetown.	33 21.6	79 16.6	1853	Dec. 24-27.	65 29.5	5.439
Columbia, Capitol Square.	34 00.0	81 02.1	1854	Feb. 24-Mar. 1.	66 07.7	5.296

## TENNESSEE.

Chattanooga, near Staunton House.	35 00	85 18	1881	July 28, 29.	66 09.7	5.307
Grand Junction, northwest of railroad depot.	35 05	89 13	1881	Sept. 9, 10.	66 00.4	5.268
Memphis.	35 09	90 03	1872	May 21.	65 37.5	5.296
Pulaski, grounds of Martin College.	35 13	87 03	1881	Aug. 23, 24, 25.	66 06.4	5.251
Tullahoma, rear of Episcopal church.	35 22	86 13	1881	Aug. 3, 5.	66 25.5	5.215
Athens, East Tennessee and Wesleyan University.	35 27	84 37	1881	July 20, 21.	66 11.7	5.290
Columbia, grounds of Episcopal Institute.	35 37	87 04	1881	Aug. 17, 18.	67 07.5	5.140
Jackson, court-house grounds.	35 39	88 51	1881	Sept. 16, 17.	66 05.4	5.272
Murfreesboro', grounds of Union University.	35 53	86 25	1881	Aug. 10, 11.	66 53.3	5.175
Knoxville.	35 58	83 55	1833	Sept.	67 06	---
Knoxville, grounds Deaf and Dumb Asylum.	35 57.3	83 56	1873	Aug. 11.	66 55.3	5.093
Rutherford, on Main street, near Corley Hotel.	36 09	89 01	1881	Sept. 20, 21.	67 13.8	5.118
Nashville.	36 10	86 48	1833	Nov.	67 05	4.568
Do.	36 09.7	86 47.6	1877	Dec. 5, 6, 7.	67 18.9	5.110
Edgefield, in front of Settle's estate.	36 15	86 46	1871	Dec. 1.	67 10.7	4.478(?)
Caryville, near Wheeler's house.	36 19	84 14	1881	July 14, 15.	67 55.7	4.972
Rogersville.	36 25	83 03	1873	Aug. 18.	68 26.2	4.982
Bristol.	36 35.9	82 11	1873	Aug. 20.	68 11.0	4.900
Bristol, Jameson's lot.	36 35.8	82 11	1881	July 9-13.	68 01.0	4.891

## TEXAS.

Mouth of Rio Grande.	25 57.4	97 07.9	1853	Nov.	52 23.6	----
Ringgold Barracks.	26 23	98 43	1853	----	52 27	----

*intensities in the United States and adjacent regions.—Continued.*

## SOUTH CAROLINA.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
12. 68	63. 11	5. 678	12. 55	C. O. Boutelle.	C. & G. S. Rpt., 1881, App. 9.
----	63. 72	----	----	Do.	Do.
----	} ----	5. 605	----	Do.	Do.
----			----	Do.	Do.
12. 86	63. 71	5. 64	12. 73	G. Davidson.	Do.
----	----	----	----	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
12. 90	} 64. 11	5. 535	12. 68	C. O. Boutelle, J. Hewson, and G. W. Dean.	C. & G. S. Rpt., 1881, App. 9.
----				C. O. Boutelle and J. B. Boutelle.	Do.
12. 72				J. B. Baylor.	Do.
13. 11	65. 10	5. 46	12. 97	C. O. Boutelle.	Do.
13. 09	65. 74	5. 32	12. 95	G. W. Dean.	Do.

## TENNESSEE.

13. 13	66. 04	5. 30	13. 05	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
12. 96	65. 88	5. 27	12. 90	Do.	Do.
----	65. 30	5. 29	12. 66	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.).
12. 96	65. 99	5. 25	12. 90	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 04	66. 30	5. 21	12. 96	Do.	Do.
13. 11	66. 08	5. 29	13. 05	Do.	Do.
13. 22	67. 00	5. 14	13. 16	Do.	Do.
13. 01	65. 97	5. 27	12. 94	Do.	Do.
13. 18	66. 77	5. 17	13. 11	Do.	Do.
----	} 66. 65	5. 09	12. 84	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
----				F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.).
13. 22	67. 11	5. 12	13. 17	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----	} 67. 37	5. 11	13. 28	J. N. Nicollet.	C. S. Rpt., 1864, App. 19.
13. 25				A. Braid.	C. & G. S. Rpt., 1881, App. 9.
----	66. 85	----	----	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.).
13. 23	67. 80	4. 97	13. 16	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----	68. 13	4. 98	13. 36	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.).
----	} 67. 89	4. 89	12. 99	Do.	Do.
13. 07				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.

## TEXAS.

----	53. 0	----	----	W. H. Emory.	C. & G. S. Rpt., 1881, App. 9.
----	53. 1	----	----	Do.	U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
TEXAS—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Fort McIntosh.	27 35	99 45	1852	----	54 07	----
Lavaca.	28 37.6	96 37.3	1868	Apr. 21-24.	57 11.2	6.574
Fort Duncan.	28 42	100 30	1852	----	55 31	----
Jupiter.	28 54.8	95 20.6	1853	May 10-17.	57 11.4	6.596
East Base, Galveston Island.	29 12.9	94 55.8	1853	Mar. 17-25.	57 42.1	6.524
San Antonio.	29 25.4	98 29.3	1878	June 10-13.	57 34.6	6.429
Dollar Point.	29 26.0	94 53.4	1848	Apr. 25-May 8.	57 53.3	6.541
Do.	29 26.0	94 53.4	1868	Feb. 24-26.	58 04.1	6.443
Do.	29 25.9	94 53.4	1878	May 30-June 4.	58 21.5	6.373
Everett's house, mouth of Sabine.	29 43.9	93 51.5	1840	Feb.	58 32.9	----
Austin.	30 16.4	97 44.2	1878	June 21-25.	58 56.7	6.269
Mouth of cañon.	31 02	105 37	1852	----	57 38	----
San Elceario.	31 35	106 16	1852	----	58 57	----
Frontera.	31 49	106 33	1852	----	59 05	----
Longview, north of depot.	32 29	94 34	1872	Apr. 15.	61 57.6	5.790
Fort Worth.	32 45.3	97 19.9	1878	July 4-9.	61 53.1	5.921

## UTAH TERRITORY.

Deseret, railroad station.	39 17.6	112 37.7	1884	Sept. 24, 25, 26.	65 34.8	5.217
Scipio.	39 23.5	112 12.4	1884	Sept. 1, 2, 3.	65 38.8	5.178
Sulphur.	39 41	113 46	1859	----	65 07	----
Nephi.	39 42.4	111 51.0	1883	Nov. 7, 8, 9.	66 26.2	5.104
Do.	39 42.4	111 51.0	1884	July 31; Aug. 1, 2	66 04.6	----
Simpson's Spring.	40 02	112 47	1859	----	66 54	----
Camp Floyd.	40 13	112 08	1859	----	66 29	----
Provo City.	40 14.8	111 40.0	1883	Nov. 11, 12, 13.	66 41.0	5.074
Do.	40 14.8	111 40.0	1884	Oct. 1, 2.	66 36.4	----
Salt Lake City, Temple Square.	40 46.0	111 53.8	1869	May 6-19.	66 58.2	5.044
Salt Lake City, east of president's house.	40 46.1	111 53.7	1878	Aug. 14, 15.	67 02.3	5.0061
Salt Lake City, Fourth Temple street, south, near Second, east.	40 46.0	111 53.8	1878	Oct. 25-31.	67 05.9	4.987
Salt Lake City, Temple Block.	40 46.0	111 53.8	1881	May 12, 13, 14.	67 02.1	5.006
Do.	40 46.1	111 53.8	1883	Nov. 15, 16, 17.	67 01.2	4.9728
Do.	40 46.0	111 53.8	1884	Oct. 22, 23, 24.	67 05.2	4.9770
Ogden, observatory.	41 13.1	111 59.9	1878	Aug. 24.	67 24.5	4.9440
Corinne, western part of town.	41 33.2	112 06.0	1881	May 5, 6, 7.	67 47.8	4.863
Kelton, western part of town.	41 45.4	113 07.5	1881	May 3, 4.	67 49.7	4.865

*intensities in the United States and adjacent regions.—Continued.*

TEXAS—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°				
----	54.8	----	----	W. H. Emory.	U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856.
12. 13	57.5	6.50	12. 10	E. Goodfellow.	C. & G. S. Rpt., 1881, App. 9.
----	56.2	----	----	W. H. Emory.	U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856.
12. 18	57.8	----	----	G. W. Dean.	C. & G. S. Rpt., 1881, App. 9.
12. 21	58.3	6.45	12. 28	Do.	Do.
11. 99	58.0	6.40	12. 08	J. B. Baylor.	Do.
12. 30	58.47	6.35	12. 14	R. H. Fauntleroy.	Do.
12. 18				E. Goodfellow.	Do.
12. 15				J. B. Baylor.	Do.
----	58.6	----	----	J. D. Graham.	Sill. J., Vol. IV, 1847. Also Am. Alm., 1881.
12. 15	59.0	6.24	12. 12	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
11. 28	----	5.90	----	W. H. Emory.	U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856.
----	58.9	----	----	Do.	Do.
----	59.0	----	----	Do.	Do.
----	61.9	5.74	12. 19	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
12. 56	61.8	5.90	12. 49	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.

## UTAH TERRITORY.

12. 62	65.55	5.217	12. 60	W. Eimbeck and G. F. Bird	MS. in C. & G. S. Office.
12. 56	65.62	5.178	12. 54	Do.	Do.
----	----	----	----	J. H. Simpson.	Mag. Var. by J. B. Stone, New York, 1878.
12. 77	66.20	5.100	12. 64	W. Eimbeck and G. F. Bird	MS. in C. & G. S. Office.
----				Do.	Do.
----	----	----	----	J. H. Simpson.	Mag. Var. by J. B. Stone, New York, 1878.
----	----	----	----	Do.	Do.
12. 82	66.60	5.070	12. 77	W. Eimbeck and G. F. Bird	MS. in C. & G. S. Office.
----				Do.	Do.
12. 89	67.05	4.972	12. 75	G. W. Dean and F. H. Agnew.	C. & G. S. Rpt., 1881, App. 9.
12. 832				T. E. Thorpe.	Proc. R. S., No. 200, 1880.
12. 81				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
12. 83	67.82	4.853	12. 86	W. Eimbeck and R. A. Marr.	Do.
12. 737				W. Eimbeck and G. F. Bird	MS. in C. & G. S. Office.
12. 783				Do.	Do.
12. 870	67.40	4.921	12. 81	T. E. Thorpe.	Proc. R. S., No. 200, 1880.
12. 87	67.79	4.851	12. 83	W. Eimbeck and R. A. Marr.	C. & G. S. Rpt., 1881, App. 9.
12. 89	67.82	4.853	12. 86	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

## VERMONT.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Bellows Falls.	43 09	72 28	1876	July 31; Aug. 1.	74 29.7	3.633
Rutland, near bank and near post-office.	43 36	72 55	1859	July 21.	75 19.8	3.464
Rutland.	43 36.5	72 55.5	1873	Oct. 16-18.	75 05.1	3.492
Do.	43 36.5	72 55.5	1879	Oct. 14-15.	74 49.5	3.550
White River Junction.	43 41	72 16	1876	Aug. 3-5.	75 07.8	3.489
Wells River.	44 09	72 05	1876	Aug. 8.	75 31.0	3.438
Montpelier.	44 17	72 36	1845	June 25.	75 16.2	3.429
Burlington.	44 28	73 12	1845	June 26.	75 37.0	3.393
Burlington, flag-staff on camp ground.	44 29.3	73 13.4	1855	Aug. 28.	75 56.8	3.425
Burlington, near college.	44 28.5	73 12.0	1873	Oct. 13-15.	75 24.2	3.427
Canaan Corner.	45 00	71 31	1845	----	76 23.5	----
Lake Memphremagog.	45 00	72 13	1845	----	76 08.4	----
Derby, near Lake Memphremagog.	45 00	72 12	1876	Aug. 12.	75 51.0	3.318

## VIRGINIA.

Knott Island, north end.	36 33.9	75 55.3	1873	Apr. 21, 22, 23.	68 52.5	4.760
Danville, Clayburn's Hill.	36 36.6	79 20	1873	July 26.	68 54.8	4.727
Marion, grounds of Marion College.	36 48	81 31	1881	June 30; July 2.	68 25.7	4.846
Norfolk, north and west of City Hall, on Smith's Creek.	36 51.4	76 17.5	1856	Sept. 9.	69 29.7	4.656
Norfolk, south and east of City Hall, open lot, Main and Water streets.	36 50.5	76 17.1	1856	Sept. 10.	69 28.2	4.667
Gosport, navy-yard, opposite Norfolk.	36 49	76 17	1865	Oct. 29.	69 38	4.713
Mount Airy.	36 51.5	79 06	1873	Aug. 21.	68 54.7	4.793
Wytheville, southeast of Boyd's Hotel.	36 55	81 05	1881	June 24, 25.	68 43.6	4.780
Cape Henry light-house.	36 55.6	76 00.4	1856	Sept. 11.	69 39.0	4.623
Do.	36 55.6	76 00.4	1874	Nov. 26, 27, 28.	69 19.0	4.629
Old Point Comfort light-house.	37 00.0	76 18.4	1856	Sept. 8.	69 31.6	4.659
Cape Charles.	37 07.3	75 58.2	1856	Sept. 7.	69 43.3	4.622
Christiansburg, rear of Baptist church.	37 11.3	80 18	1873	Aug. 23.	69 01.1	4.717
Burkeville.	37 13.2	78 12	1873	July 23.	69 20.4	4.609
Petersburg, near geodetic station, Roslyn.	37 14.4	77 23.9	1852	Aug. 6-13.	69 17.3	4.640
Williamsburg, grounds of William and Mary College.	37 16.3	76 42.7	1874	Dec. 4, 10.	69 27.6	4.631
Scott, close to the bay.	37 20.5	75 54.1	1856	Sept. 6.	70 01.5	4.571
Wolftrap.	37 24.0	76 14.7	1871	May 13-20.	69 46.8	4.610
Lynchburg, top of bluff opposite freight station.	37 24.7	79 08.7	1873	July 20.	69 45.3	4.646

*intensities in the United States and adjacent regions.—Continued.*

## VERMONT.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	° 73. 87	3. 665	13. 20	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected—Sch.]
13. 68	} 74. 34	3. 564	13. 20	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 57				T. C. Hilgard.	Do.
13. 56				J. B. Baylor.	Do.
----	74. 49	3. 521	13. 17	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected—Sch.]
----	74. 88	3. 470	13. 30	Do.	Do.
----	74. 40	3. 495	13. 00	J. Locke.	Smithsonian Cont's to Know., Vol. III, 1852.
----	} 74. 78	3. 497	13. 32	Do.	Do.
14. 10				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 60				T. C. Hilgard.	Do.
----	75. 52	----	----	J. D. Graham.	Sill. J., Vol. IV, 1847.
----	75. 27	----	----	Do.	Do.
----	75. 21	3. 350	13. 12	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected—Sch.]

## VIRGINIA.

13. 21	68. 40	4. 806	13. 06	A. T. Mosman.	C. & G. S. Rpt., 1881, App. 9.
----	68. 44	4. 773	12. 99	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 18	} 68. 24	4. 859	13. 11	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 29				C. A. Schott.	Do.
13. 31				Do.	Do.
13. 542	} 68. 94	4. 760	13. 25	W. Harkness.	Smithsonian Cont. to Know., No. 239, Wash., 1873. Cruise of the Monadnock.
----				F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 17	68. 44	4. 839	13. 17	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 17	68. 50	4. 793	13. 08	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 29	} 68. 96	4. 690	13. 06	C. A. Schott.	Do.
13. 11				T. C. Hilgard.	Do.
13. 32	68. 93	4. 744	13. 19	C. A. Schott.	Do.
13. 34	69. 12	4. 707	13. 20	Do.	Do.
----	68. 55	4. 763	13. 02	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	68. 87	4. 655	12. 91	Do.	Do.
13. 12	68. 73	4. 721	13. 01	G. W. Dean and A. D. Bache.	C. & G. S. Rpt., 1881, App. 9.
13. 20	69. 02	4. 671	13. 05	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 38	69. 42	4. 656	13. 25	C. A. Schott.	Do.
13. 34	69. 27	4. 665	13. 18	A. T. Mosman.	Do.
----	69. 29	4. 692	13. 27	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
VIRGINIA—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Richmond, Mayo's Island.	37 31.7	77 26.0	1856	Sept. 19.	69 47.7	4.609
Natural Bridge, in grove front of hotel.	37 35	79 22	1873	Aug. 26.	69 42.9	4.602
Joynes, edge of salt water marsh.	37 41.7	75 36.9	1856	Sept. 4.	70 21.2	4.488
Tangier.	37 47.9	75 59.3	1871	June 16–21.	70 11.6	4.542
Covington, garden of McCurdy House.	37 48	79 59.5	1873	Aug. 28.	69 47.3	4.584
Covington, rear of McCurdy House.	37 48	79 59.5	1881	June 15, 16.	69 33.5	4.615
Snead, yard of Snead's house.	37 58.3	75 26.2	1856	Sept. 2.	70 31.0	4.448
Charlottesville.	38 02	78 30	1834	----	71 09	----
Do.	38 01.0	78 31	1873	July 16.	70 20.0	4.428
Staunton, on hill.	38 08.9	79 04	1873	Sept. 1.	69 54.1	4.489
Fredericksburg, Brown's Island.	38 18.2	77 27.4	1856	Sept. 17.	70 37.9	4.449
Clark Mountain.	38 18.6	78 00.2	1871	Aug. 29; Sept. 1.	71 40.2(?)	4.390
Harrisonburg.	38 25	78 52	1873	Sept. 2.	70 28.9	4.437
Culpeper.	38 28.5	78 00	1873	July 14.	70 42.0	4.492
Mount Vernon.	38 42.5	77 05.3	1844	Apr. 11.	70 55.5	4.401
Bull Run.	38 52.8	77 42.3	1871	Oct. 18; Nov. 6.	71 18.9	4.334
Peach Grove.	38 55.2	77 13.8	1869	Oct. Nov. -	71 05.0	4.346
Strasburg, opposite Kelley's house.	38 59.5	78 21.6	1873	July 12.	70 56.2	4.375

## WASHINGTON TERRITORY.

Fort Vancouver.	45 37.5	122 39.5	1830	Nov.	69 39.7	4.442
Fort Vancouver, room and garden.	45 37.5	122 39.5	1839	----	69 22.2	4.475
Fort Vancouver.	45 37.5	122 39.5	1860	May 3.	69 17.4	4.6180
Vancouver.	45 37.5	122 39.5	1881	Oct. 26, 27.	----	4.547
Lower Cascades, Rapids of Columbia River.	45 40	121 50	1830	----	69 27	4.442
Lower Cascades.	45 39	122 00	1881	Oct. 22, 23.	----	4.496
Dalles, eight-mile camp north side of Columbia River.	45 40	120 49	1860	June 1.	70 04.5	----
Walla-Walla, town.	46 03.9	118 20.5	1881	Sept. 25, 26.	70 46.5	4.349
Walla-Walla River, near Old Fort.	46 03	118 50	1830	July.	70 14	4.349
Wallula, near old Fort Walla-Walla.	46 07	118 55	1881	Sept. 29, 30; Oct. 1.	70 24.9	4.391
Dry Creek.	46 09	118 18	1861	----	70 49	4.290
Ainsworth, southwest of southern house of town.	46 14	119 03	1881	Aug. 22, 23.	70 37.8	4.332
Cape Disappointment.	46 16.5	124 02	1830	Sept. and Dec.	69 30.3	4.436
Cape Disappointment, Baker's Bay, landing place.	46 17	124 03	1839	----	69 26.9	4.394
Cape Disappointment, on beach.	46 16.7	124 02.8	1873	Oct. 22–30.	69 13.7	4.537
Do.	46 16.7	124 02.8	1881	Oct. 13–15.	69 17.7	4.482

*Intensities in the United States and adjacent regions.—Continued.*

VIRGINIA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885-0}$	$H_{1885-0}$	$F_{1885-0}$		
13. 34	69. 20	4. 694	13. 22	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
----	69. 24	4. 648	13. 11	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 35	69. 75	4. 573	13. 21	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 40	69. 68	4. 596	13. 23	A. T. Mosman.	Do.
----	69. 34	4. 629	13. 12	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13. 21				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 34	69. 92	4. 533	13. 21	C. A. Schott.	Do.
----	----	----	----	Patterson,	Sill. J., 1838. E. Loomis.
----	69. 86	4. 474	12. 99	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	69. 43	4. 535	12. 91	Do.	Do.
13. 42	70. 03	4. 534	13. 27	C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 96	----	4. 444	----	C. O. Boutelle.	Do.
----	70. 01	4. 482	13. 11	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	70. 23	4. 537	13. 42	Do.	Do.
13. 47	70. 41	4. 459	13. 30	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 53	70. 81	4. 388	13. 35	C. O. Boutelle.	C. & G. S. Rpt., 1881, App. 9.
13. 41	70. 54	4. 407	13. 23	Do.	Do.
----	70. 47	4. 421	13. 23	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.

## WASHINGTON TERRITORY.

12. 78	69. 2	4. 49	12. 64	D. Douglas.	Rpt. Brit. Asso., Vol. VI, London, 1838, and C. S. Rpt., 1861, App. 22.
12. 60				E. Belcher.	Phil. Trans. R. S., 1841 & 1843.
13. 052				R. W. Haig.	Phil. Trans. R. S., 1864, Bound. Com. Capt. R. W. Haig, R. A. $\theta$ , H & F obs'd.
----				J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
12. 66	----	4. 44	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, London, 1838.
----	----	4. 488	----	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
13. 003	70. 1	4. 37	12. 84	R. W. Haig.	B. S. Phil. Trans. R. S., 1864.
13. 21	70. 7	4. 341	13. 13	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
12. 87	----	----	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI., London, 1838.
13. 10	70. 4	4. 383	13. 07	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
----	70. 8	4. 23	12. 86	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
13. 06	70. 6	4. 328	13. 03	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
12. 67	69. 2	4. 490	12. 64	D. Douglas.	Rpt. Brit. Asso., Vol. VI, London, 1838, and C. S. Rpt., 1861, App. 22.
12. 52				E. Belcher.	Do.
12. 79				W. Eimbeck.	C. & G. S. Rpt., 1881, App. 9.
12. 68				H. E. Nichols.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
WASHINGTON TERRITORY—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Pomeroy, northeast corner Main and Second streets.	° / 46 31	° / 117 40	1881	Sept. 20.	° / 70 20.2	4.406
Tukannon River.	46 32	118 00	1861	----	70 23	4.382
Sixty Mile Well, on ridge, west side of coulée.	46 49	118 50	1881	Aug. 25.	70 44.8	4.321
Cow Creek.	46 53	118 10	1861	----	71 57	4.302
Olympia, on block between Union and Eleventh and Columbus and Main streets.	47 02.3	122 54.0	1881	Nov. 4.	----	4.283
Nisqually.	47 07	122 38	1859	Jan. 31.	70 40.0	----
Lugenbeel's Creek.	47 09	118 06	1861	----	71 20	4.230
Sprague, west of railroad track.	47 19	118 10	1881	Aug. 27, 28.	71 05.8	4.299
Seattle, edge of bluff, bank of Duwamish Bay.	47 35.9	122 20.0	1871	Sept. 21; Oct. 4, 5.	71 08.9	4.252
Seattle.	47 35.9	122 20.0	1881	Nov. 10, 11.	----	4.217
Spokane Falls, on Wolverton's place.	47 43	117 23	1881	Aug. 30.	72 13.3	4.170
Peon's Prairie.	47 44	117 14	1861	----	72 07	4.100
Spokane Ferry.	47 49	117 49	1861	----	71 53	4.133
Chemikane.	48 00	117 45	1861	May 19.	72 04.2	----
Port Discovery.	48 02	122 50	1792	May.	74 30	----
Okinakane (Oakanagan).	48 05	119 27	1833	April.	71 45	4.033
Port Townsend.	48 07.0	122 45.0	1881	Nov. 17, 18.	----	4.144
Scarborough Harbor.	48 21.8	124 38.0	1852	Sept. 7, 8.	----	4.170
Nee-ah Bay, near Waddah Island.	48 22	124 36.8	1855	Aug. 13-22.	71 07.0	4.276
Nee-ah Bay.	48 21.8	124 38.0	1881	Oct. 10, 11.	71 04.4	4.144
Colville Depot.	48 34	117 52	1861	----	72 31	3.976
Fort Colville, old B. B. C. Barracks.	48 40	118 05	1861	Mar. 26; Apr. 23.	72 41.9	3.9923
Birch Bay.	48 53	122 45	1792	June.	73 13	----
Point Roberts.	48 59	123 01	1858	March.	71 42.6	4.112
Semi-ah-moo Spit.	48 59.4	122 46.2	1858	----	72 15	----
Skagit.	49 00	121 03	1860	----	72 39	3.933
Camp Osogoos.	49 00	119 24	1861	----	72 35	----

## WEST VIRGINIA.

Alderson, southwest part of town.	37 45	80 40	1881	June 11, 13.	69 25.9	4.672
Charleston, on road leading to ferry.	38 21.0	81 38.1	1881	June 6, 7.	69 57.2	4.577
Parkersburg, foot of Court street, on bluff.	39 16.0	81 34	1881	May 30, 31.	70 58.6	4.402
Clarksburg, near academy.	39 16.9	80 20.4	1880	Dec. 10, 11.	70 44.8	4.413
Martinsburg, grounds of Randolph's house.	39 26.7	77 57	1873	July 10.	71 25.1	4.231
Wheeling.	40 05	80 43	1840	Aug.	72 08.9	4.053
Do.	40 05	80 44	1844	Mar. 24.	72 19.3	4.164
Do.	40 05	80 44	1845	Apr. 30.	72 13.7	4.176
Wheeling, south end of Zane's Island.	40 03.3	80 44	1881	May 25, 26.	71 54.5	4.208

*intensities in the United States and adjacent regions.—Continued.*

## WASHINGTON TERRITORY—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 09	70. 3	4. 398	13. 05	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
----	70. 4	4. 32	12. 88	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
13. 10	70. 7	4. 313	13. 05	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
----	(71. 9)	4. 24	(13. 65)	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
----	----	4. 275	----	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
13. 116	70. 7	4. 28	12. 95	R. W. Haig.	B. S. Phil. Trans. R. S., 1864.
----	71. 3	4. 17	13. 01	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. S. Office.
13. 27	71. 0	4. 291	13. 18	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
13. 16	} 71. 1	4. 210	13. 00 {	S. R. Throckmorton.	Do.
----				J. S. Lawson.	Do.
13. 66	72. 2	4. 162	13. 61	Do.	Do.
----	72. 1	4. 04	13. 14	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
----	71. 9	4. 08	13. 13	Do.	Do.
13. 343	72. 1	4. 05	13. 18	R. W. Haig.	B. S. Phil. Trans. R. S., 1864.
----	----	----	----	G. Vancouver.	A voyage of discovery, by G. Vancouver, 3 vols., London, 1798.
12. 88	----	4. 03	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, London, 1838.
----	----	4. 136	----	J. S. Lawson.	C. & G. S. Rpt., 1881, App. 9.
----	} 71. 07	4. 147	12. 78 {	G. Davidson and J. Rockwell.	Do.
13. 21				W. P. Trowbridge.	Do.
12. 78				H. E. Nichols.	Do.
----	72. 5	3. 92	13. 04	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
13. 397	72. 7	3. 93	13. 22	R. W. Haig.	B. S. Phil. Trans. R. S., 1864. $\theta$ , H & F obs'd.
----	----	----	----	G. Vancouver.	A voyage of discovery by G. Vancouver, 3 vols., London, 1798.
----	71. 7	4. 05	12. 90	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
----	72. 2	----	----	Richards.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----	72. 6	3. 88	12. 98	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
----	72. 6	----	----	Do.	Do.

## WEST VIRGINIA.

13. 32	69. 24	4. 692	13. 24	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13. 35	69. 76	4. 590	13. 27	Do.	Do.
13. 50	70. 79	4. 415	13. 40	Do.	Do.
13. 38	70. 54	4. 428	13. 29	Do.	Do.
----	70. 95	4. 277	13. 11	F. E. Hilgard and J. M. Poole.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
----	} 71. 71	4. 227	13. 47 {	A. D. Bache.	C. S. Rpt., 1862, App. 19.
13. 72				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----				Do.	Phil. Trans. R. S., 1846 and Smithsonian Cont's to Know., Vol. III, 1852.
13. 55	----	----	----	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
WISCONSIN.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Platteville, south of village.	42 43	90 14	1841	Sept.	73 17.4	----
Mineral Point.	42 50	89 54	1839	Nov. 5.	73 20.6	3.953
Mineral Point, west of Franklin House.	42 50	89 54	1841	Sept.	73 23.2	----
Hickok's, 10 miles from Blue Mounds.	42 58	90 00	1841	Sept.	73 39.5	----
Blue Mounds.	43 01.5	89 51	1839	Oct. 29.	73 41	3.887
Blue Mounds, near E. Brigham's.	43 01.5	89 51	1841	Sept.	73 34.9	----
Campbell's, 10 miles from Blue Mounds.	43 01	89 40	1841	Sept.	73 28.1	----
Milwaukee, corner Fourth and Poplar streets.	43 02.8	87 55.1	1859	Aug. 20.	73 57	3.858
Milwaukee, Spring street, between Fourth and Fifth streets.	43 02.8	87 55.1	1873	Aug. 22.	73 43	3.897
Prairie du Chien.	43 03	96 01	1839	Oct. 24.	73 16.6	3.988
Madison, southeast of capitol.	43 04.0	89 22.5	1839	Nov. 2.	{ 74 04.4 74 03.0 }	3.878
Do.	43 04.0	89 22.5	1841	Sept.	74 06.5	----
Madison, Magnetic Observatory, grounds of University.	43 04.5	89 24.2	1876	Oct. 3, 17.	73 54.8	3.891
Do.	43 04.5	89 24.2	1877	Aug. & Sept.	73 55.5	3.913
Madison, University Station.	43 04.5	89 24.2	1878	Aug. 29, 30.	----	3.903
Madison, Observatory and South Stations.	43 04.5	89 24.2	1878	Sept. 8-15.	73 56.5	3.899
Madison, Observatory and Farm Station.	43 04.5	89 24.8	1878	Nov. 21, 26.	73 55.1	3.894
Madison, Observatory, South and Farm Stations.	43 04.5	89 24.5	1879	Sept. 23; Oct. 9.	73 50.5	3.908
Madison, Observatory and Farm Station.	43 04.5	89 24.8	1880	Sept. 15-25.	73 47.0	3.903
Madison, University and Farm Station.	43 04.5	89 25.2	1881	Dec. 16-19.	73 48.1	3.898
La Crosse, near Main Street Park.	43 48.8	91 15.1	1876	Sept. 18-22.	73 57.2	3.8443
La Crosse, Court-House Square.	43 48.8	91 14.8	1877	Sept. 24, 25, 26.	73 48.7	3.880
Superior City, near Robbins' house.	46 43	92 04	1870	Sept. 20.	76 28	3.227
Superior City, Fourth street near Becker avenue	46 40	92 04	1880	Aug. 21, 23.	76 26.1	3.261
La Pointe.	46 47	90 58	1843	July 21.	76 56	3.206

## WYOMING.

Sherman.	41 07.8	105 23.6	1872	Aug. 3, 5, 6.	68 53.3	4.768
Cheyenne.	41 07	104 49	1872	Oct. 22.	68 58.1	4.705
Cheyenne, between court and school houses.	41 07.8	104 48.9	1878	Aug. 9.	69 02.0	4.7348
Cheyenne, corner Seventeenth and Dodge streets.	41 08	104 49.0	1878	Sept. 13-17.	68 54.4	4.738
Fort Bridger.	41 20	110 24	1858-9	----	68 05	----
Green River, opposite court-house.	41 31.6	109 28.2	1878	Aug. 26.	68 20.5	4.8069
Green River, south of station house.	41 32	109 29	1878	Oct. 5-10.	68 17.1	4.813
Fort Fred. Steele, south of army hospital.	41 46.7	106 56.8	1878	Sept. 26-29.	69 00.2	4.707
Fort Laramie.	42 12	104 31	1858-7	----	70 03	----

*intensities in the United States and adjacent regions.—Continued.*

## WISCONSIN.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°				
13.79	72.9	----	----	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
----	73.0	3.96	13.55	J. Locke.	Sill. Jour., 1840, and Trans. Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
13.84	73.3	----	----	Do.	Do.
----	73.3	3.90	13.57	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
----				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
13.956	73.1	----	----	Do.	Do.
13.900	73.48	3.90	13.72	W. P. Smith.	U. S. Lake Survey, Capt. G. G. Meade, Detroit, 1859, and C. B. Comstock, 1882.
13.87				A. N. Lee.	U. S. Lake Survey, Genl. C. B. Comstock, MS. 1873, and Rpt. of 1882.
14.11	72.9	4.00	13.60	J. Locke.	Sill. J., Vol. XXXIX, 1840, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI.
14.04	72.69	3.907	13.91	Do.	Sill. J., Vol. XXXIX, 1840, and Trans. Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
14.13				E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
14.095				F. E. Hilgard.	C. & G. S. Rpt., 1881, App. 9.
14.045				A. Braid.	Do.
14.04				G. Hinrichs.	MS. in C. & G. S. Office.
13.98				W. Suess.	C. & G. S. Rpt., 1881, App. 9.
13.97				J. B. Baylor.	Do.
13.907				D. Mason.	Do.
13.92				Do.	Do.
13.790				W. Suess.	Do.
13.90	73.63	3.87	13.73	C. F. Powell.	Rpt. Chief of Engineers, U. S. A., for 1877, Part 2.
14.18				A. Braid.	C. & G. S. Rpt., 1881, App. 9.
13.16	68.9	4.74	13.17	C. B. Comstock.	U. S. Lake Survey, MS. 1875, & C. B. Comstock's Rpt., 1882.
13.024				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13.01	68.3	4.81	13.01	J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13.14				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.

## WYOMING.

13.24	68.9	4.77	13.25	W. Suess and R. D. Cutts.	C. & G. S. Rpt., 1881, App. 9.
13.232	68.9	4.74	13.17	T. C. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser.
13.16				T. E. Thorpe.	Proc. R. S., No. 200, 1880.
----	----	----	----	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
13.024	68.3	4.81	13.01	J. H. Simpson.	Mag. Var. by J. B. Stone, New York, 1878.
13.01				T. E. Thorpe.	Proc. R. S., No. 200, 1880.
13.14	69.0	4.71	13.14	J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
----	----	----	----	Do.	Do.
----	----	----	----	J. H. Simpson.	Mag. Var. by J. B. Stone, New York, 1878.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

WYOMING—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Little Sandy Creek.	42 15	109 40	1858. 8	----	69 00	----
Sweetwater River.	42 30	108 35	1858. 8	----	69 35	----
La Banta River.	42 35	105 22	1858. 8	----	70 15	----
Sweetwater River.	42 38	107 25	1858. 8	----	69 53	----
Greasewood Creek.	42 40	107 07	1858. 8	----	70 01	----
West of Deer Creek.	42 53	105 57	1858. 8	----	70 29	----
Mile-post 42.	44 59. 8	110 11. 6	1882	Aug. 16.	71 17. 5	4. 303
Northeast corner of Wyoming Territory.	44 59. 9	104 03. 0	1882	June 7.	72 41. 0	4. 096
Little Missouri River station.	44 59. 9	104 24. 6	1882	June 24.	72 43. 7	4. 124
Mile-posts 283, 284.	45 00. 0	105 20. 2	1882	July 7.	72 14. 0	4. 207
Mile-post 185.	45 00. 4	107 21. 0	1882	July 16.	72 10. 4	4. 198

## DOMINION OF CANADA,

[To longitude 75° west.]

Yarmouth, Nova Scotia.	43 49. 9	66 07. 2	1881	Nov. 7, 8.	74 35	3. 474
Weymouth, Nova Scotia.	44 24. 4	65 59. 8	1881	Nov. 10.	74 45	3. 461
Halifax, Nova Scotia, Dock-yard Observatory.	44 39	63 37	1834	May 27.	75 33	} 3. 22
Do.	44 39	63 37	1837	June 7.	74 58	
Do.	44 39	63 37	1838. 5	----	74 45	
Do.	44 39	63 36	1847. 5	----	75 37	
Halifax, Nova Scotia drill-ground, Dock-yard.	44 39. 8	63 35. 2	1873	May 13, 15, 16.	74 48. 2	3. 385
Halifax, Nova Scotia, Dock-yard.	44 39. 5	63 35. 0	1879	Sept. 8–10.	74 39. 2	3. 452
Do.	44 39. 5	63 35	1881	Nov. 2.	74 29	3. 459
Annapolis, Nova Scotia.	44 44. 5	65 31. 1	1881	Nov. 14, 15.	74 53	3. 428
Windsor, Nova Scotia.	44 59. 6	64 08. 4	1881	Nov. 21, 22.	74 49	3. 423
Do.	45 10	64 16	1847	----	75 41	----
Lake Memphremagog, East shore.	45 01	72 15	1845	----	76 08. 6	----
Stanstead, Q., garden of hotel, near Anglican Church.	45 02	72 07	1842	Sept. 12.	76 19. 2	3. 222
Cornwall, orchard behind Chesley's Inn.	45 02	74 50	1845	June 16.	76 16. 4	----
Chamcook.	45 07. 5	67 04. 9	1859	Oct. 13, 17, 20.	76 09. 4	3. 241
Kentville, Nova Scotia.	45 12	64 46	1847	----	75 46	----
St. John, New Brunswick.	45 14	66 03	1847	----	75 56	----
St. John's, Q., behind hotel, ¼ mile above bridge.	45 17	73 15	1842	Sept. 14.	77 00. 1	----
Isle d'Uval, opposite La Chine.	45 25. 0	73 44	1843	Apr. 30.	77 03. 1	----
Isle Madame, Cape Breton Island.	45 28	61 03	1862	----	75 31	----
Arichat, Isle Madame, Nova Scotia.	45 30. 5	61 01. 3	1881	Oct. 26.	74 43	3. 435
Montreal.	45 31	73 30	1833	----	77 06	----
Do.	45 30	73 33	1838	----	76 19	----
Montreal, St. Helen's Isle, near Artillery Bar racks.	45 31	73 32	1842	Sept. 16.	77 13. 1	3. 064

*intensities in the United States and adjacent regions.—Continued.*

## WYOMING—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
---	o	---	---	J. H. Simpson.	Mar. Var. by J. B. Stone, New York, 1878.
---	---	---	---	Do.	Do.
---	---	---	---	Do.	Do.
---	---	---	---	Do.	Do.
---	---	---	---	Do.	Do.
---	---	---	---	Do.	Do.
13. 416	71. 27	4. 303	13. 40	B. A. Colonna.	MS. record in C. & G. S. Office.
13. 762	72. 66	4. 096	13. 74	Do.	Do.
13. 889	72. 71	4. 124	13. 88	Do.	Do.
13. 788	72. 21	4. 207	13. 77	Do.	Do.
13. 712	72. 15	4. 198	13. 69	Do.	Do.

## DOMINION OF CANADA,

[To longitude 75° west.]

13. 07	74. 28	3. 486	12. 87	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
13. 16	74. 45	3. 473	12. 96	Do.	Do.
12. 94	74. 22	3. 460	12. 72	E. Home.	Phil. Trans. R. S., 1838, Pt. I, Capt. Sir E. Home.
---				Do.	Do.
---				Estcourt.	Phil. Trans. R. S., 1872, E. Sabine.
13. 07				Keely.	Do.
12. 914	74. 58	3. 440	12. 94	Maclear and Bromley.	Voy. of H. M. S. Challenger, Capt. G. S. Nares, Vol. II, London, 1882.
13. 04				J. B. Baylor.	C. & G. S. Rpt., 1881, App. 9.
12. 93				S. W. Very.	Do.
13. 14				Do.	Do.
13. 07	74. 65	3. 435	12. 98	Do.	Do.
---				G. W. Keely.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
---	75. 27	---	---	A. W. Whipple.	Phil. Trans. R. S., 1846.
13. 624	75. 45	3. 270	13. 02	J. H. Lefroy.	Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883.
13. 789	75. 40	3. 340	13. 25	C. Younghusband.	Do.
13. 54	75. 16	3. 363	13. 13	G. W. Dean and A. D. Bache.	C. & G. S. Rpt., 1881, App. 9.
---	74. 87	---	---	G. W. Keely.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
---	75. 04	---	---	Do.	Do.
---	76. 13	---	---	J. H. Lefroy.	Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883.
13. 643	76. 18	3. 110	13. 02	Do.	Do.
---	74. 48	3. 447	12. 88	Shadwell.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
13. 03				S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
---				Back.	Sill. J., Vol. XXXIX, 1840, E. Loomis.
---				Estcourt.	Phil. Trans. R. S., 1840.
13. 720	---	---	---	J. H. Lefroy.	Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. $\theta$ , H, and F. obs'd.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[To longitude 75° west.]

Name of station.	Latitude <i>φ.</i>	West longi- tude <i>λ.</i>	Year.	Month.	Dip <i>θ.</i>	Horizontal force <i>H.</i>
	° /	° /			° /	
Montreal, St. Helen's Isle, Artillery Barracks.	45 31	73 32	1843	Apr. 25, 29.	77 08.8	----
Montreal.	45 31	73 32	1843	Aug.	----	3.109
Montreal, garden, foot of mountain.	45 31	73 33.3	1845	June 20.	77 08.5	----
Montreal, grounds of McGill University.	45 30.5	73 34.9	1859	July 20.	76 51.4	3.111
Do.	45 30.5	73 34.9	1879	Sept. 25.	76 25.7	3.191
La Combe's farm.	45 33	74 09	1843	May 2.	76 50.6	----
Pointe du Chene, left bank.	45 37	74 50	1843	May 3.	76 55.4	----
Richmond Junction, P. Q.	45 41	72 03	1876	Aug. 15.	75 47.7	3.380
Kingsey, Q., in garden of Captain Cox.	45 46	72 12	1842	Sept. 10.	77 40.0	----
Louisburg.	45 53	60 00	1862	----	76 00	----
Fredericton, New Brunswick.	45 55	66 38.2	1847	----	76 59	----
Sorel, east of Roman Catholic church.	46 02	73 03	1842	Sept. 8.	77 16.4	----
Sydney, Cape Breton, Nova Scotia.	46 08.6	60 11.6	1881	Oct. 21, 22.	75 10	3.286
Woodstock, New Brunswick.	46 09	67 35	1847	----	77 05	----
Cape Breton.	46 16	60 08	1862	----	76 03	----
Three Rivers, garden of Mr. Bell.	46 21	72 32	1842	Sept. 6.	77 10.7	----
Becancour, Province of Quebec.	46 22	71 33	1876	Aug. 17, 18.	76 54.5	3.118
St. Pierre de Miquelon, Gulf of St. Lawrence.	46 46.9	56 10.6	1872	June 20-29.	74 37.9(?)	3.193
Do.	46 46.8	56 10.6	1881	Oct. 11-14.	75 02	3.255
Quebec:						
In 1842, near artillery barracks.	46 49.5	71 14.2	1842	Sept. 1.	77 15.3	} 3.040
In 1845, near Wolfe and Montcalm mon- uments.	46 48.6	71 13.3	1845	June 23.	77 08.8	
Quebec, near Wolfe's Monument.	46 48.4	71 14.5	1859	July 18, 19.	77 17.5	2.991
Do.	46 48.4	71 14.5	1879	Sept. 16, 19.	76 45.1	3.104
St. Thomas, Province of Quebec.	46 59	70 33	1876	Aug. 24, 25.	77 11.7	3.024
Edmonston, New Brunswick.	47 15	68 20	1876	Aug. 31.	77 18.3	2.970
St. John's, Newfoundland, grounds about Gov- ernment house.	47 34.4	52 41.9	1881	Sept. 26, 27, 28.	74 37	3.300
St. John's, Newfoundland, old cemetery on Church Hill.	47 34.5	52 42	1883	June 28.	74 47	3.292
Riviere du Loup-en-bas, Province of Quebec.	47 51	69 25	1876	Aug. 28-30.	77 31.6	2.947
Brandypot Island, St. Lawrence River.	47 53	69 42	1830	----	78 35	----
Gaspe Basin, Gulf of St. Lawrence.	48 50	64 30	1832	----	78 50	----
Twillingate, Newfoundland.	49 39.2	54 46.2	1881	July 9-16.	75 57	3.050
Battle Harbor, Caribou Islands, Labrador.	52 16.3	55 34.5	1881	Sept. 6, 7, 8, 9.	77 16	2.770

*intensities in the United States and adjacent regions.—Continued.*

## DOMINION OF CANADA—Continued.

[To longitude 75° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 762	°			J. H. Lefroy.	Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883.
13. 62	76. 05	3. 200	13. 27	A. D. Bache.	C. S. Rpt., 1861, App. 22.
13. 536				C. Younghusband.	Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883.
13. 68				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 60				J. B. Baylor.	Do.
13. 855	75. 97	3. 205	13. 22	J. H. Lefroy.	Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883.
13. 622	76. 05	3. 133	13. 00	Do.	Do.
----	75. 15	3. 412	13. 31	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.]
13. 687	76. 80	2. 971	13. 01	J. H. Lefroy.	Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883.
----	75. 01	----	----	Shadwell.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----	76. 09	----	----	G. W. Keely.	Do.
13. 751	76. 40	3. 076	13. 08	J. H. Lefroy.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.
12. 84	74. 87	3. 298	12. 64	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
----	76. 19	----	----	G. W. Keely.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----	75. 06	----	----	Shadwell.	Do.
13. 843	76. 31	3. 119	13. 18	J. H. Lefroy.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.
----	76. 26	3. 150	13. 26	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.]
12. 05 (?)	74. 73	3. 256	12. 36	E. Goodfellow.	C. & G. S. Rpt., 1881, App. 9.
12. 60				S. W. Very.	Do.
13. 702	76. 31	3. 111	13. 15	J. H. Lefroy and C. Younghusband.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , $H$ , & $F$ obs'd.
13. 60				C. A. Schott.	C. & G. S. Rpt., 1881, App. 9.
13. 54				J. B. Baylor.	Do.
----				F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.]
----	76. 56	3. 056	13. 15	Do.	Do.
----	76. 66	3. 002	13. 01	Do.	Do.
12. 44	74. 47	3. 328	12. 43	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
----				W. H. Lamar and F. W. Ellis.	U. S. Signal Corps, Service Notes XIV, Wash., 1884.
----	76. 89	2. 979	13. 13	F. E. Hilgard.	C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.]
----	77. 58	----	----	Bayfield.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----	77. 90	----	----	Do.	Do.
12. 56	75. 63	3. 062	12. 34	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
12. 57	76. 95	2. 782	12. 32	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
DOMINION OF CANADA.—Continued.

[Between longitudes 75° and 90° west.]

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Amherstburg, C. W., Mr. Gordon's garden.	42 06	83 03	1845	Oct. 22.	73 30.3	----
Sarnia, C. W., garden near the ferry.	42 58	82 22	1845	Oct. 25, 27.	74 15.7	----
Niagara Falls, near Clifton House.	43 04	79 05	1841	Sept.	74 54.7	----
Do.	43 04	79 05	1845	Oct. 18.	74 46.8	----
Cape Ippewash, Lake Huron.	43 13	82 00	1860	May 8.	74 46	3.633
Niagara Village, C. W., garden of Royal Engineer's quarters.	43 15	79 08	1843	Mar. 11.	74 45.6	----
Hamilton, C. W., in yard of Farmers' Inn.	43 16	79 50	1842	Dec. 29.	74 56.7	} ----
			1845	Oct. 31.	74 54.1	
Toronto, Magnetic Observatory.	43 39.4	79 23.3	1841	12 months.	75 16.6	----
Do.	43 39.4	79 23.3	1842	Oct. 26.	75 14.7	3.535
Do.	43 39.4	79 23.3	1842	12 months.	75 16.4	----
Do.	43 39.4	79 23.3	1843	Aug.	75 11.4	3.537
Do.	43 39.4	79 23.3	1843	12 months.	75 14.7	----
Toronto, 1½ miles east of Observatory.	43 39	79 22	1844	June 19.	75 12.5	3.542
Toronto, Magnetic Observatory.	43 39.4	79 23.3	1844	June 20.	75 13.4	3.540
Do.	43 39.4	79 23.3	1844	12 months.	75 14.8	----
Do.	43 39.4	79 23.3	1845	Do.	75 15.5	3.5476
Do.	43 39.4	79 23.3	1846	Do.	75 15.1	3.5419
Do.	43 39.4	79 23.3	1847	Do.	75 15.3	3.5381
Do.	43 39.4	79 23.3	1848	Do.	75 18.3	3.5339
Do.	43 39.4	79 23.3	1849	Do.	75 18.8	3.5368
Do.	43 39.4	79 23.3	1850	Do.	75 20.0	3.5322
Do.	43 39.4	79 23.3	1851	Do.	75 20.4	3.5299
Do.	43 39.4	79 23.3	1852	Do.	75 20.5	3.5154
Do.	43 39.4	79 23.3	1853	Do.	75 22.2	----
Do.	43 39.4	79 23.3	1854	Do.	75 23.0	----
Do.	43 39.4	79 23.3	1855	Hand F, Sept. to Dec.	75 23.5	3.5154
Do.	43 39.4	79 23.3	1856	12 months.	75 24.1	3.5049
Do.	43 39.4	79 23.3	1857	Do.	75 24.3	3.4883
Do.	43 39.4	79 23.3	1858	Do.	75 24.4	3.4900
Do.	43 39.4	79 23.3	1859	June 25 and 30.	75 24	3.480
Do.	43 39.4	79 23.3	1859	12 months.	75 25.0	3.4811

*intensities in the United States and adjacent regions.—Continued.*

DOMINION OF CANADA.—Continued.

[Between longitudes 75° and 90° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 760	72. 81	3. 970	13. 43	J. H. Lefroy.	Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883.
13. 812	73. 57	3. 808	13. 46	Do.	Do.
-----	74. 15	3. 650	13. 36	J. N. Nicollet.	Am. Phil. Soc., Vol. VIII, 1843.
13. 757				J. H. Lefroy.	Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883.
13. 940	73. 97	3. 717	13. 46	W. P. Smith.	U. S. Lake Sur. Rpt., 1882, Genl. C. B. Comstock.
13. 852	74. 07	3. 695	13. 46	J. H. Lefroy.	Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883.
13. 824	74. 23	3. 655	13. 45	J., and J. H. Lefroy.	Do.
-----				C. J. B. Riddell and C. Younghusband.	Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875.
13. 896				J. H. Lefroy.	Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
-----				C. Younghusband.	Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875.
-----				A. D. Bache.	C. S. Rpt., 1862, App. 19.
-----				C. Younghusband.	Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875.
13. 88				J. Locke.	Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844.
13. 90				Do.	Do.
-----				C. Younghusband and J. H. Lefroy.	Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875.
13. 942				J. H. Lefroy.	Do.
13. 914				Do.	Do.
13. 901				Do.	Do.
13. 931				Do.	Do.
13. 952				Do.	Do.
13. 950				Do.	Do.
13. 948				Do.	Do.
13. 892				Do.	Do.
-----				J. H. Lefroy and G. T. Kingston.	Do.
-----				G. T. Kingston.	Do.
13. 940				Do.	Do.
13. 905				Do.	Do.
13. 844				Do.	Do.
13. 852				Do.	Do.
13. 800				W. P. Smith.	U. S. Lake Sur., Capt. G. G. Meade, Detroit, 1859.
13. 825				G. T. Kingston.	Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Toronto, Magnetic Observatory.	° / 43 39.4	° / 79 23.3	1860	12 months.	° / 75 24.6	3.4792
Do.	43 39.4	79 23.3	1861	Do.	75 23.8	3.4839
Do.	43 39.4	79 23.3	1862	12 months.	75 23.2	3.4853
Do.	43 39.4	79 23.3	1863	Do.	75 21.5	3.4891
Do.	43 39.4	79 23.3	1864	Do.	75 20.9	3.4932
Do.	43 39.4	79 23.3	1865	Do.	75 21.0	3.4925
Do.	43 39.4	79 23.3	1866	Do.	75 19.2	3.4931
Do.	43 39.4	79 23.3	1867	Do.	75 18.8	3.4976
Do.	43 39.4	79 23.3	1868	Do.	75 20.1	3.4980
Do.	43 39.4	79 23.3	1869	Do.	75 16.7	3.4989
Do.	43 39.4	79 23.3	1870	Do.	75 16.3	3.4984
Do.	43 39.4	79 23.3	1871	Do.	75 16.8	3.5003
Do.	43 39.4	79 23.3	1885	April.	74 52	3.5911
Goodrich, C. W., in garden foot of hill.	43 45	81 41	1845	Oct. 28.	75 04.8	----
Goodrich, C. W., ¼ mile south of Town Hall.	43 44	81 43	1860	July 19.	75 02	3.575
Coburg, C. W., in yard adjoining Parry's house.	43 56	78 10	1843	Apr. 16.	75 27.2	----
Belleville, C. W., in Dr. Reilly's garden.	44 09	77 25	1843	Apr. 17.	77 01.0	----
Kingston, C. W., Artillery Square, Stewart's Pt. and Common.	44 13	76 28.6	1842	Nov. 11	77 18.9	----
			1843	Apr. 18.	77 18.1	----
			1845	June 10.	77 14.5	----
Kingston, C. W., Stewart's Pt.	44 12	76 29.0	1845	June 11.	----	----
Kingston, C. W., the Common near penitentiary.	44 13	76 30.0	1845	June 11.	----	----
Barrie, C. W., garden of Bingham's Hotel.	44 21	79 41	1843	Jan. 24.	75 49.9	----
Brockville, C. W., Rockford's Hotel.	44 32	75 41	1845	June 13.	76 18.9	---
Prescot, Canada West, 500 yards from river, near fort.	44 35	75 30	1843	Apr. 19.	78 42.5	----
Penetanguishene.	44 47	79 58	1825	Apr. 18.	76 16.0	----
Penetanguishene, near Mrs. Wallace's inn.	44 47	79 58	1843	Jan. 26.	76 04.2	} 3.3224
			1844	Nov. 11.	76 20.1	
Williamsburg, Canada West, garden of Broueffle's inn.	44 55	75 07	1843	Apr. 20.	76 30.8	----
Aylmer, left bank.	45 15	75 58	1843	May 5.	76 41	----
Ottawa.	45 21	75 42	1856	Aug.	76 42	----
Chat Falls.	45 26	76 32	1843	May 6.	75 07	----
Fox's Point, right bank.	45 32	75 22	1843	May 4.	76 35.3	----
Grande Calumet portage.	45 45	76 40	1843	May 7.	76 44.4	----
Fort Coulonge.	45 54.9	76 45	1843	May 8.	77 29.7	----
Pointe au Croix, Lake Huron.	45 55.5	81 02	1843	May 16.	76 31.3	----
Ricollet's Fall.	45 57	80 30	1843	May 15.	76 45.4	----

*intensities in the United States and adjacent regions.—Continued.*

## DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1883.0}$	$H_{1883.0}$	$F_{1883.0}$		
13. 811	°			G. T. Kingston.	Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875.
13. 817	74. 88	3. 589	13. 759	Do.	Do.
13. 814				Do.	Do.
13. 803				Do.	Do.
13. 811				Do.	Do.
13. 810				Do.	Do.
13. 783				Do.	Do.
13. 796				Do.	Do.
13. 817				Do.	Do.
13. 769				Do.	Do.
13. 761				Do.	Do.
13. 776				Do.	Do.
13. 756				C. Carpmæl.	Letter of Director Carpmæl of June 8, 1885.
13. 833	74. 31	3. 641	13. 46	J. H. Lefroy.	Diary Mag. Sur., Canada; Sir J. H. Lefroy, London, 1883.
13. 841				W. P. Smith.	U. S. Lake Sur, Rpt., 1882; Genl. C. B. Comstock.
----				H.	Diary Mag. Sur. Canada, Sir. J. H. Lefroy, London, 1883.
----	74. 46	----	----	Do.	Do.
----	76. 32	----	----	Do.	Do.
14. 971	76. 60	3. 355	14. 48	J. H. Lefroy and	Do.
15. 060				C. Younghusband.	
15. 110				C. Younghusband.	
14. 449				Do.	
15. 465	75. 14	----	----	J. H. Lefroy.	Do.
----	75. 63	3. 306	13. 32	C. Younghusband.	Do.
13. 711	78. 02	----	----	J. H. Lefroy.	Do.
----	75. 38	3. 378	13. 38	J. Franklin.	Do.
14. 077				J. H. Lefroy.	{ Diary Mag. Sur. Canada, Sir J. H. Lefroy. London, 1883. $\theta$ , H & F obs'd.
13. 964	75. 82	3. 311	13. 52	Do.	Diary Mag. Sur. Canada, Sir. J. H. Lefroy, London, 1883.
13. 836	76. 00	3. 241	13. 40	Do.	Do.
----	75. 90	----	----	K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858.
13. 916	74. 43	3. 659	13. 63	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
13. 877	75. 90	3. 273	13. 44	Do.	Do.
13. 832	76. 05	3. 227	13. 39	Do.	Do.
13. 911	76. 80	3. 066	13. 43	Do.	Do.
13. 903	75. 83	3. 295	13. 46	Do.	Do.
14. 130	76. 07	3. 291	13. 67	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[Between longitude 75° and 90° west.]

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Frazer Bay, Lake Huron.	46 00	81 40	1843	May 17.	77 05.6	----
Pointe Baptême.	46 05	77 26	1843	May 9.	77 19.1	----
Fort La Cloche.	46 07	82 03	1843	May 18.	76 50.2	----
Snake Island.	46 10	82 40	1843	May 18.	77 05.5	----
Lake Nipissing.	46 11	79 48	1843	May 14.	77 09.5	----
Port des deux Joachims.	46 12	77 40	1843	May 10.	77 03.8	----
Trou Portage.	46 15	78 16	1843	May 11.	77 24.4	----
Little River, first portage.	46 15.4	78 44	1843	May 12.	77 28.5	----
Tessalon Point.	46 17	83 33	1843	May 19.	76 59.3	----
Trout Lake, south side.	46 18.5	79 13	1843	May 13.	77 21.7	----
Pointe aux Pins.	46 29.9	84 29	1843	May 20.	77 13.4	----
Saint Mary, opposite Saulte de Ste. Marie.	46 30.9	84 21.5	1844	Nov. 4.	----	3.0330
Do.	46 30.9	84 21.5	1845	May.	77 19.5	----
Gros Cap.	46 32	84 43	1841	Aug.	77 05.3	----
Pointe au Crepe.	46 58.0	84 44	1843	May 21.	77 11.5	----
Cape Gargantua.	47 36.9	85 05	1843	May 21.	77 56.1	3.1900
Foot of Long Portage.	47 54.6	84 45.0	1880	July 24; Sept. 8.	----	2.818
Michipicoten, Hudson's Bay Post.	47 56.0	84 54	{ 1843 1844	{ May 23. Oct. 30.	{ 78 07.2	2.8701
Michipicoten, fort.	47 56.0	84 54	1845	----	78 05.2	----
Michipicoten, Hudson's Bay Company's Grounds.	47 56.0	84 50.6	1880	July 21; Sep. 9.	----	2.860
Otter Island, east side.	48 07	86 07	1843	May 24.	79 43.6	----
Big Stony Portage, upper end.	48 13.6	84 15.3	1880	July 27; Sept. 7.	----	2.750
Tip-Top, near shore.	48 15	86 08	1871	Aug. 26.	78 56	2.708
Sandy Beach, Dog Lake.	48 17.8	84 00.7	1880	July 28.	----	2.784
Thunder Cape.	48 20	88 52	1843	May 28.	78 23.2	----
Fairy Point, Missinaibi Lake.	48 20.7	83 44.0	1880	July 29.	----	2.751
Fort William.	48 23.5	89 13.5	1825	May 11.	78 20.0	----
Do.	48 23.5	89 13.5	{ 1843 1844	{ May 29, 31. Oct. 10, 11.	{ 78 04.7	2.8720
Do.	48 23.5	89 13.5	1845	----	78 11.0	----
Portage Ecarté.	48 25	89 44	1843	June 2.	77 13.5	----
Missinaibi, Post of Hudson's Bay Company.	48 28.6	83 28.4	1880	Aug. 2.	----	2.720
Dog Portage.	48 39	89 30	{ 1843 1844	{ June 3. Oct. 9.	{ 78 26.8	2.8361
White River, or Riviere Blanche.	48 31.6	86 14	1844	Oct. 21.	78 33.1	2.8020
The Pic.	48 35.3	86 15	{ 1843 1844	{ May 25. Oct. 17.	{ 78 36.6	2.7262
The Pic, or Fort Pic.	48 35.3	86 15	1845	----	78 34.0	----

*intensities in the United States and adjacent regions.—Continued.*

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 906	76. 40	3. 160	13. 44	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
13. 775	76. 63	3. 078	13. 31	Do.	Do.
----	76. 15	----	----	Do.	Do.
13. 850	76. 40	3. 148	13. 39	Do.	Do.
13. 861	76. 47	3. 135	13. 40	Do.	Do.
13. 830	76. 37	3. 150	13. 37	Do.	Do.
13. 914	76. 72	3. 088	13. 44	Do.	Do.
13. 956	76. 79	3. 081	13. 48	Do.	Do.
14. 020	76. 30	3. 211	13. 56	Do.	Do.
13. 949	76. 67	3. 106	13. 47	Do.	Do.
14. 080	76. 53	3. 168	13. 60	Do.	Do.
13. 824	76. 63	3. 091	13. 37	Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ (1845) & H obs'd.
----				J. Rae.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
---	76. 40	----	----	E. Loomis.	Am. Phil. Soc., Vol. VIII, 1843.
13. 959	76. 50	3. 149	13. 49	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
15. 265	77. 24	3. 244	14. 69	Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd. Local disturbance.
----	----	2. 835	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
14. 015	77. 41	2. 901	13. 31	J. H. Lefroy.	{ Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F Obs'd.
----				J. Rae.	Phil. Trans. R. S., 1846, Sir E. Sabine.
----				S. W. Very.	C. & G. S. Rpt., App. 9.
13. 568	79. 04	2. 474	13. 01	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
----	----	2. 766	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
13. 790	78. 25	2. 762	13. 56	C. B. Comstock	U. S. Lake Sur. Rpt., 1882.
----	----	2. 800	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
14. 218	77. 70	2. 916	13. 69	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
----	----	2. 767	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
----	77. 40	2. 928	13. 42	J. Franklin.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 078				J. H. Lefroy.	{ Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
----				J. Rae.	Phil. Trans. R. S., 1846, Sir E. Sabine.
14. 013	76. 53	3. 153	13. 54	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1843.
----	----	2. 736	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
14. 124	77. 76	2. 892	13. 64	J. H. Lefroy.	{ Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
14. 117	77. 89	2. 822	13. 45	Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd.
13. 901				Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
----	----	----	----	J. Rae.	Phil. Trans. R. S., 1846, Sir E. Sabine.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Foot of Swampy Grounds Portage.	48 41.5	83 23.6	1880	Sept. 5.	----	2.752
Peninsula Harbor.	48 44	86 28	1824	----	78 34	----
Battle Island, Lake Superior.	48 45	87 33	{ 1843 1844	May 26. Oct. 14.	{ 76 24	3.2124
Simpson's Island.	48 49	87 45	1843	May 27.	78 53.6	----
St. Paul's Portage, southwest end.	48 49.5	83 23.5	1880	Sept. 3.	----	2.643
Moose River, above small cascade.	49 07.7	83 21.9	1880	Sept. 3.	----	2.589
Twin Portage, head of portage.	49 12.3	83 24.4	1880	Aug. 6.	----	2.638
Albany Rapids, Moose River.	49 22.0	83 29.8	1880	Sept. 2.	----	2.540
Kettle Portage.	49 47.1	83 16.4	1880	Aug. 8.	----	2.474
Storehouse Portage, head of.	50 04.1	83 16.1	1880	Aug. 29.	----	2.470
Near Cedar Island, Moose River.	50 21.1	82 42.2	1880	Aug. 28.	----	2.453
Near Small Falling Brook, Moose River.	50 36.4	82 07.2	1880	Aug. 11, 12.	----	2.312
Ship Sands, near Moose Factory.	51 08	80 44	1846	----	81 02	----
Moose Factory, Hudson's Bay.	51 15	80 56	1846	----	81 30	----
Do.	51 15.4	80 40.5	1880	Aug. 15, 20.	----	2.110
Fort Albany, Hudson's Bay.	51 22	82 38	1775	----	79 20	----

## BRITISH POSSESSIONS, NORTHWEST AMERICA.

[South of latitude 51° and west of longitude 90° west.]

Second Portage.	48 14.2	92 25	1843	June 11.	77 40.1	----
Lake à la Crosse, east end.	48 24	92 04	1843	June 10.	77 51.0	----
Victoria, Vancouver Island.	48 26	123 25	1858	----	71 39	----
Esquimalt, Vancouver Island.	48 26	123 27	1859	Jan. 24; Mar. 22.	71 34.1	4.1192
Laurel Point, Victoria, Vancouver Island.	48 25.4	123 22.5	1862	----	71 39	----
Esquimalt, Vancouver Island.	48 26	123 27	1862	----	71 52	----
Victoria, Vancouver Island.	48 25.8	123 22.2	1880	May 4.	71 22.1	4.106
Esquimalt, Vancouver Island.	48 25.4	123 26.3	1881	Sept. 29, 30; Oct. 1.	71 30.3	4.080
Sturgeon Lake.	48 27.5	92 38	1843	June 12.	77 44.8	----
Rainy Lake.	48 33.4	92 50	1843	June 13.	77 47.9	----
French Portage.	48 35	91 08.4	1843	June 8.	78 20.4	----
Portage of the Two Rivers.	48 35	91 23	1843	June 9.	77 49.4	----
Fort Frances, Hudson's Bay house.	48 36.6	93 26.7	1825	May 27.	77 18.1	----
Do.	48 36.6	93 26.7	{ 1843 1844	June 14. Sept. 29.	{ 77 30	3.0404
Do.	48 36.6	93 26.7	1845	----	77 32	----
Rainy River, north side.	48 41	94 31	1843	June 16.	77 57.4	----
Savannah.	48 53	90 03.2	1825	May 20.	78 39.1	----
Savannah Portage.	48.53	90 03.2	1843	June 6.	78 21.8	----
Prairie Portage.	48 57.5	90 01.5	{ 1843 1844	June 5. Oct. 7.	{ 78 26.1	2.8342

• intensities in the United States and adjacent regions.—Continued.

DOMINION OF CANADA—Continued.  
[Between longitudes 75° and 90° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	°				
----	----	2. 768	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
----	77. 51	----	----	Bayfield.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
13. 659	75. 71	3. 268	13. 24	J. H. Lefroy.	{ Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd. Local disturbance.
14. 020	78. 21	2. 755	13. 48	Do.	
----	----	2. 659	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
----	----	2. 605	----	Do.	Do.
----	----	2. 654	----	Do.	Do.
----	----	2. 556	----	Do.	Do.
----	----	2. 490	----	Do.	Do.
----	----	2. 486	----	Do.	Do.
----	----	2. 469	----	Do.	Do.
----	----	2. 328	----	Do.	Do.
14. 07	80. 34	2. 258	13. 46	T. E. L. Moore.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 12	80. 81	2. 152	13. 48	Do.	Do.
----	----	2. 126	----	S. W. Very.	C. & G. S. Rpt., 1881, App. 9.
---	----	----	----	Hutchins.	Hansteen's Erdmagnetismus, Christiania, 1819.

BRITISH POSSESSIONS, NORTHWEST AMERICA.

[South of latitude 51° and west of longitude 90° west.]

14. 026	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.
14. 063	----	----	----	Do.	Do.
----	71. 4	4. 076	12. 78	K. Friesach.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
13. 103				R. W. Haig.	B. S. Phil. Trans. R. S., 1864. $\theta$ , H and F obs'd.
----				Richards.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----				Do.	Do.
12. 85				W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
12. 87				H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9. $\theta$ , H & F obs'd.
14. 077	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.
14. 095	----	----	----	Do.	Do.
14. 069	----	----	----	Do.	Do.
14. 031	----	----	----	Do.	Do.
----	}	----	----	J. Franklin.	Do.
14. 023				J. H. Lefroy.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. $\theta$ , H and F obs'd.
----				J. Rae.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.
14. 309	----	----	----	J. H. Lefroy.	Do.
----	}	----	----	J. Franklin.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. Dip 98° supposed a misprint for 78°.
14. 107				J. H. Lefroy.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883.
14. 086				Do.	Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. $\theta$ , H and F obs'd.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Ashtnolou station.	49 00	120 00	1860	Aug. 17, 18.	72 27.0	4.0105
Inchwointum station.	49 00	118 28	1860	Nov. 13.	72 48.8	----
Wigwam River station.	49 00	114 45	1861	July 15; Aug. 14.	73 30.8	3.8268
Akamina station.	49 01	114 04	1861	Aug. 2.	73 42.7	----
Camp Semi-ah-moo.	49 01	122 46	1857	Sept.	72 02	4.0905
Station Semi-ah-moo.	49 00.7	122 46.2	1857	Sept. 8, 9; Oct. 7, 8.	71 57.0	4.1032
Sumass Prairie.	49 01	122 12	1858	Oct. 4, 5; Nov. 10.	72 22.0	4.0509
Schweltza Lake station.	49 02	122 00	1859	July 4, 5.	72 03.9	----
Chilukweyuk Lake.	49 02	121 23	1859	Sept. 7.	73 31.0	----
Chilukweyuck camp.	49 06	121 23	1859	----	72 22.2	4.023
Camp No. 11.	49 07	115 16	1861	----	73 37.8	----
On Ashtnolou River.	49 10	120 00	1860	July.	72 36.9	----
Namaimo, Vancouver Island.	49 10	124 00	1862	----	71 54	----
Departure Bay, Vancouver Island.	49 12.6	123 58.5	1880	May 6.	71 29.2	----
Do.	49 12.6	123 57	1881	Oct. 6, 7.	71 42.2	4.066
New Westminster, Frazer River.	49 13	122 53	1862	----	72 15	----
Hecate Bay, Vancouver Island.	49 15	125 56	1861	----	72 37	----
Burrard Inlet.	49 16	123 10	1859	----	72 14	----
Lake of the Woods (probably), Falcon Island.	49 19	94 40	1843	June 17.	78 03.7	----
Lake of the Woods.	49 25	94 37	1843	June 18.	78 16.7	----
Joseph's Prairie, Camp No. 14.	49 31	115 35	1861	----	73 50.4	3.758
Nootka Sound, Vancouver Island, Resolution Cove.	49 36	126 37	1778	April.	72 29	----
Nootka.	49 36	126 37	1791	Aug. 16, 17.	70 20.7	----
Nootka Sound, Vancouver Island.	49 36	126 37	1792	Oct.	73 56	----
Nootka Sound, Friendly Cove.	49 35.5	126 37.5	1881	Sept. 26, 27.	71 33.0	4.083
Henry Bay, Vancouver Island.	49 36	124 51	1860	----	72 25	----
Station S, the gap in Cypress Hills.	49 37.8	109 51.4	1880	July 31.	75 20.4	----
Station V, at Willow Creek, near McLeod.	49 45.3	113 24.0	1880	Aug. 17, 18.	74 46.3	----
Rat Portage.	49 45.9	94 33.3	{ 1843 1844	{ June 20. Sept. 5.	{ 78 07.5	2.8734
Fort Garry (upper fort).	49 53.2	97 15.6	1843	June 30, 31; July 3.	78 18.8	2.8491
Winnipeg, C. P. R. station (Fort Garry?).	49 53(?)	97 16(?)	1882	May 24.	79 50.4	----
Station R, at Maple Creek.	50 02.6	108 51.4	1880	July 24.	75 50.1	----
Winnipeg River, left bank.	50 10.2	95 12	1843	June 21.	79 10.6	----
Slave Falls, portage.	50 14.7	95 40	1843	June 23.	78 57.1	----
Red River, 6 miles from mouth.	50 18.2	96 52	1843	July 4.	78 34	----
Station W, on road from McLeod to Catgaro.	50 22.4	113 48.8	1880	Aug. 20.	74 44.1	----
Station P, north end Old Woman's Lake.	50 28.9	106 46.8	1880	July 20.	76 51.2	----

*intensities in the United States and adjacent regions.—Continued.*

## BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
13. 321	72. 2	----	----	R. W. Haig.	B. S. Phil. Trans. R. S., 1864. $\theta$ , H and F obs'd.
13. 272	72. 6	----	----	Do.	B. S. Phil. Trans. R. S., 1864.
13. 497	73. 2	----	----	Do.	B. S. Phil. Trans. R. S., 1864. $\theta$ , H and F obs'd.
13. 587	73. 4	----	----	Do.	B. S. Phil. Trans. R. S., 1864.
----	} 71. 8	----	----	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
----				Do.	Do.
13. 366	72. 1	----	----	R. W. Haig.	B. S. Phil. Trans. R. S., 1864, Capt. R. W. Haig, R. A. $\theta$ , H and F obs'd.
13. 285	71. 8	----	----	Do.	B. S. Phil. Trans. R. S., 1864.
13. 180	} 72. 2	----	----	Do.	Do.
----				J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
----	73. 4	----	----	Do.	Do.
13. 226	72. 4	----	----	R. W. Haig.	B. S. Phil. Trans. R. S., 1864.
----	} 71. 5	4. 062	12. 80	Richards.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----				W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
12. 95				H. E. Nichols.	Do.
----				Richards.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----	72. 0	----	----	Do.	Do.
----	72. 4	----	----	Do.	Do.
----	72. 0	----	----	Do.	Do.
14. 110	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Gen. Sir J. H. Lefroy, London, 1883.
14. 044	----	----	----	Do.	Do.
----	73. 6	3. 76	13. 32	J. S. Harris.	U. S. N. W. Bound. Com.; MS. in C. & G. S. Office.
----	} 71. 5	4. 08	12. 86	J. Cook.	Encyc. Met. London, 1848; Hansteen's Erdmagnetismus, Christiania, 1819.
----				Don A. Malaspina.	Bode's Astr. Jahrb., Berlin, 1828.
----				G. Vancouver.	A Voyage of Discovery, by Capt. G. Vancouver, 3 vols., London, 1798.
12. 90				H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
----	72. 2	----	----	Richards.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----	75. 3	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
----	74. 7	----	----	Do.	Do.
14. 023	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H and F obs'd.
14. 050	} 79. 8	----	----	Do.	Do.
----				W. Ogilvie.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
----	75. 8	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
14. 204	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 094	----	----	----	Do.	Do.
14. 094	----	----	----	Do.	Do.
----	74. 7	----	----	W. H. King.	Geol. Sur. Canada, MS. commun'd by G. M. Dawson.
----	76. 8	----	----	Do.	Do.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
North Harbor, Quatsino Sound, Brit. Col.	50 29.4	128 03.6	1881	Sept. 22, 24, 25.	71 41.3	4.050
Port Neville.	50 31	126 04	1860	----	72 19	----
Lake Winnipeg.	50 33.4	96 36	1843	June 27.	79 05.1	----
Do.	50 35	96 35.6	1843	June 26.	78 34.4	----
Fort Alexander.	50 36.9	96 22	1825	June 6.	78 47.1	----
Do.	50 36.9	96 22	1834	----	78 54	----
Do.	50 36.9	96 22	1843 1844	June 25. Sept. 19.	78 58.4	2.6984
Thompson's River.	50 41	120 11	1833	April.	73 43	3.611
Station A, on Ellice & Touchwood Trail.	50 42.5	101 59.9	1880	May 22–31.	77 51.5	----
Beaver Harbor.	50 43	127 25	1860	----	72 37	----
Station K, near Fort on Appelle.	50 46.3	103 48.0	1880	July 5.	77 23.2	----
Anchorage Cove, Kingcome Inlet, Brit. Col.	50 52.8	126 11.7	1881	Aug. 3.	72 46.1	3.808
Waddington Harbor, Brit. Col.	50 54.0	124 49.5	1881	July 30.	71 58.6	4.005

BRITISH POSSESSIONS, NORTHWEST AMERICA.

[North of latitude 51° and west of longitude 90° west.]

Land Survey station.	51 00.6	111 40.5	1882	Aug. 6.	76 13.2	----
Station X, on north bank of Bow River.	51 01.9	114 00.0	1880	Sept. 10.	75 23.4	----
Lake Winnipeg.	51 03.6	96 56	1843	July 5.	79 11.8	----
Do.	51 04	96 26	1844	Sept. 18.	79 31.5	2.6398
Station O, near Elbow of S. branch.	51 04.8	106 37.0	1880	July 17.	77 03.9	----
Land Survey station.	51 05	110 15	1882	July 15.	76 14.1	----
Station Y, Morleyville.	51 10.5	114 48.5	1880	Sept. 15.	75 17.0	----
Station J, on Appelle trail.	51 12.5	103 53.8	1880	June 30; July 1.	77 51.6	----
Station I, near H. B. House.	51 21.6	104 00.0	1880	June 28.	77 53.2	----
Station H, on Pelly's trail.	51 32.0	103 42.6	1880	June 27, 28.	78 12.0	----
Lake Winnipeg.	51 34	96 43	1844	Sept. 17.	79 06.1	2.7211
Do.	51 36.7	96 53	1843	July 6.	79 38.0	----
Station G.	51 38.7	103 08.0	1880	June 21, 25.	78 21.2	----
Lake Winnipeg, opposite Tete du Chien.	51 44.5	97 02	1844	Sept. 16.	79 39	2.7634
Station D, on right bank of Assiniboine.	51 44.8	102 00.8	1880	June 16, 17.	78 34.7	----
Lake Winnipeg, island east of Bear Island.	51 46	97 00	1843	July 7.	79 28.3	----
Station C, at Swan River barracks.	51 54.4	101 57.3	1880	June 12.	78 34.5	----

*intensities in the United States and adjacent regions.—Continued.*

## BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
12. 89	71. 7	4. 05	12. 90	H. E. Nichols.	C. & G. S. Rept., 1881, App. 9.
----	} 72. 0	----	----	Richards.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----				J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 128	----	----	----	J. H. Lefroy.	Do.
----	} ----	----	----	J. Franklin.	Do.
----				Back.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
14. 098				J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
12. 88	----	----	----	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872.
----	77. 8	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
----	72. 3	----	----	Richards.	Phil. Trans. R. S., 1872.
----	77. 3	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
12. 86	72. 73	3. 804	12. 81	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
12. 94	71. 94	4. 001	12. 91	Do.	Do.

## BRITISH POSSESSIONS, NORTHWEST AMERICA.

[North of latitude 51° and west of longitude 90° west.]

----	76. 2	----	----	W. Ogilvie.	MS. commun'd by the Hon. E. Deville & M. H. Dall, Feb. 21, 1885.
----	75. 4	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
14. 090	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 516	----	----	----	Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd.
----	77. 0	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
----	76. 2	----	----	W. Ogilvie.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
----	75. 3	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
----	77. 8	----	----	Do.	Do.
----	77. 9	----	----	Do.	Do.
----	78. 2	----	----	Do.	Do.
14. 393	} ----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd.
14. 462				Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
----	78. 3	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
15. 382	----	----	----	J. H. Lefroy.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson. $\theta$ & H obs'd.
----	78. 6	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
14. 414	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
----	78. 6	----	----	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.

TABLE I—*Observed magnetic dips and horizontal and total magnetic*  
 BRITISH POSSESSIONS, NORTHWEST AMERICA.—Continued.  
 [North of latitude 51° and west of longitude 90° west.]

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Port McLaughlin, British Columbia.	52 08.4	128 10.3	1881	Aug. 5, 6, 7.	73 12.1	3.785
Rose Harbor, Queen Charlotte Island, British Columbia.	52 09.1	131 15.0	1881	Sept. 19, 20.	72 30.2	3.885
Lake Winnipeg, near Berens River.	52 20.9	97 10	1844	Sept. 14.	80 24.4	2.4010
Do.	52 22.6	97 12	1843	July 8.	80 39.2	----
Do.	52 31.6	97 18	1843	July 10.	80 05.5	----
Fort Alexandria.	52 33	122 29	1833	May.	74 50	3.386
Station e, Battleford, near telegraph office.	52 43	108 17	1880	Nov. 2.	77 49.4	----
Carlton House.	52 50.8	106 32	1844	Aug. 26.	78 30.7	2.7438
Station a, at crossing of Pipestone Creek.	53 04.3	113 35.5	1880	Sept. 25.	77 00.2	----
Fort Edmonton.	53 31.9	113 30.3	1844	Aug. 16, 17.	77 54.2	2.9440
Station b, in valley near Edmonton.	53 32.0	113 30	1880	Oct. 6.	77 30.5	----
Fort Pitt.	53 34.1	109 47.2	1844	Aug. 22.	78 41.0	2.7777
Station d, on fourteenth base-line, at crossing, Battleford.	53 35.9	111 24.0	1880	Oct. 17.	77 56.8	----
Norway House, old site.	53 41.6	98 01.4	1819	Oct. 7.	83 40	----
Do.	53 41.6	98 01.4	1843	Aug. 12.	80 45.4	----
Cumberland House.	53 56.7	102 19.2	1819	Dec. 1.	83 12 (?)	----
Do.	53 56.7	102 19.2	1820	June 11.	84 34 (?)	----
Do.	53 56.7	102 19.2	1825	June 28.	80 21.1	----
Do.	53 56.7	102 19.2	{ 1843 1844 }	Aug.	80 25.0	{ 2.3411 2.3724 }
Do.	53 56.7	102 19.2	1884	June 17.	80 23.3	----
Norway House, new position.	53 59.6	98 03.9	{ 1843 1844 }	July., Aug., Sept.	81 10.0	2.1750
Do.	53 59.6	98 03.9	1884	July 23; Oct. 4.	81 12.8	----
Frazer's Lake.	54 03	124 40	1833	June.	75 48	3.219
Land Survey Station.	54 21.3	114 00	1883	Jan. 1.	77 58.1	----
Fort Assiniboine.	54 21.7	114 28.6	1844	Aug. 11.	78 15.2	----
Stuart's Lake.	54 27	124 20	1833	June.	76 09	3.161
Port Simpson, British Columbia.	54 33.5	130 23.8	1862	----	74 53	----
Do.	54 33.6	130 25.5	1881	Aug. 9, 10, 12.	74 21.0	3.503
Oxford House.	54 56	95 30	1843	Aug. 3.	82 38.8	----

*intensities in the United States and adjacent regions.—Continued.*

## BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[North of latitude 51° and west of longitude 90° wes..]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 10	73. 2	3. 785	13. 10	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
12. 92	72. 5	3. 885	12. 92	Do.	Do.
14. 396	}	}	}	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd.
14. 150				Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 125				Do.	Do.
12. 98	---	---	---	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872.
---	77. 8	---	---	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
13. 782	---	---	---	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd.
---	77. 0	---	---	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
14. 000	} 77. 5	}	}	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
---				W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
14. 154	---	---	---	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & H obs'd.
---	77. 9	---	---	W. H. King.	Geol. Sur. Canada; MS. commun'd by G. M. Dawson.
---	}	}	}	J. Franklin.	Encyc. Met. London, 1848, Art. Mag.; Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 162				J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
---				J. Franklin.	Encyc. Met. London, 1848, Art. Magnetism. Dip defective by $3\frac{1}{2}^\circ$ or $4^\circ$ .
---	}	}	}	Do.	Do.
---				Do.	Do.
---				Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 143	} 80. 4	}	}	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
14. 042				O. J. Klotz.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
14. 098	} 81. 2	} 2. 151	} 14. 06	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , H & F obs'd.
14. 063				O. J. Klotz.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
13. 14	---	---	---	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872.
---	78. 0	---	---	W. Ogilvie.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
---	---	---	---	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
13. 21	---	---	---	D. Douglas.	Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872.
---	} 74. 3	} 3. 503	} 12. 95	Richards.	Phil. Trans. R. S., 1872.
12. 98				H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
14. 192	---	---	---	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[North of latitude 51° and west of longitude 90° west.]

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Land Survey Station.	55 10	114 03.5	1883	May 10.	78 29.1	----
Observatory Inlet.	55 15.5	129 44	1793	----	75 54.5	----
Isle à la Crosse.	55 26.8	107 54	1825	July 11.	79 55.0	----
Fort à la Crosse.	55 26.8	107 54	1843	Sept. 9.	80 09.8	2.3889
Land Survey Station.	55 32.5	116 08.6	1883	Oct. 3.	78 15.1	----
Fort Lesser Slave Lake.	55 32.6	116 00	1844	Aug. 5.	78 39.0	2.7298
Fort Dunvegan.	55 55.6	118 28.5	1844	July 22–25.	78 46.2	2.7243
Land Survey Station.	56 08	117 50.6	1883	Sept. 22.	78 17.2	----
York, Factory, Hudson's Bay.	56 59.9	92 26	1843	July 24–26.	83 47.2	1.5052
Do.	56 59.9	92 26	{ 1845 1846	{ Nov. 5. May 16. }	83 42.6	----
Do.	56 59.9	92 26	1847	Sept. 18.	83 47.0	----
Do.	56 59.9	92 26	1857	Aug.	83 53	----
Do.	56 59.9	92 26	1884	Sept. 11.	83 46.9	----
Fort Vermilion or Fort Lefroy.	58 24.5	115 58.6	1844	July 12.	80 48.0	2.2482
Fort Chipewyan, Lake Athabasca.	58 43	111 18.7	1825	July 24.	81 26.1	----
Do.	58 43	111 18.7	{ 1843 1844	{ Sept., Oct. Feb., Mar., July. }	81 36.8	2.0267
Do.	58 43	111 18.7	1883	Sept. 17.	81 20.6	----
Fort Churchill.	58 43.8	94 14	1846	June 29; July 4.	84 46.8	----
Fort Resolution, Great Slave Lake.	61 10.7	113 46	1844	June 22.	82 44.4	1.7636
Fort Simpson.	61 51.7	121 25.3	1825	Aug. 5.	81 53.1	----
Do.	61 51.7	121 25.3	1844	Mar. 28; May 10.	81 52.2	1.9533
Fort Norman, west side of river, or old site.	64 40.6	124 44.8	1844	May 28; June 2.	82 34.3	1.7652
Fort Good Hope, Mackenzie River.	66 16	128 31	1844	May 29.	82 55.9	1.6918
Fort Confidence.	66 54	118 49	1839	June.	84 48	----
Do.	66 54	118 49	1848	Oct., Nov., Dec.	84 50.2	1.203
Do.	66 54	118 49	1849	Jan., Feb., Mar.	84 51.0	1.208
Richardson's Chain.	69 01	137 25	1826	----	82 22	----
Clarence Bay, Arctic Ocean.	69 38	140 51	1826	----	83 27	----

*intensities in the United States and adjacent regions.—Continued.*

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[North of latitude 51° and west of longitude 90° west.]

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
13. 734	78. 5	2. 740	13. 73	W. Ogilvie.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
----	----	----	----	G. Vancouver.	Encyc. Met. London, 1848.
----	}	----	}	J. Franklin.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
14. 012				J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , $H$ & $F$ obs'd.
13. 572	78. 3	2. 75	13. 57	W. Ogilvie.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
13. 872	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & $H$ obs'd.
14. 000	----	----	----	Do.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , $H$ & $F$ obs'd.
13. 614	78. 3	2. 76	13. 61	W. Ogilvie.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
14. 051	}	83. 8	13. 93	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , $H$ & $F$ obs'd.
----				J. Rae.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
----				Do.	Do.
----				R. B. Blakiston.	Do.
13. 926				O. J. Klotz.	MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885.
14. 022	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , $H$ & $F$ obs'd.
----	}	81. 3	}	J. Franklin.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
13. 885				J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ , $H$ & $F$ obs'd.
----				H. P. Dawson.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
----				J. Rae.	Do.
13. 956	----	----	----	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & $H$ obs'd.
----	}	----	}	J. Franklin.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
13. 808				J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$ & $H$ obs'd.
13. 653	----	----	----	Do.	Do.
13. 681	----	----	----	Do.	Do.
----	}	84. 8	}	T. Simpson.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
13. 58				J. Richardson.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
13. 60				Do.	Do.
----	----	----	----	J. Franklin.	Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII.
----	----	----	----	Do.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
WEST INDIA ISLANDS AND BERMUDAS.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Trinidad, Port of Spain.	10 39	61 33	1822	----	39 02	---
Do.	10 39	61 33	1830	----	39 00	----
Santa Marta, Colombia, South America.	11 15	74 15	1857	----	36 34	----
Curaçoa.	12 06	68 56	1833	----	38 39	----
Barbadoes, Carlisle Bay.	13 05	59 37	1835	May 11.	43 45.9	} 6.65
Do.	13 05	59 37	1836	Jan. 5.	43 28.8	
Barbadoes.	13 05	59 37	1846	----	43 57	----
Antigua, fort in English Harbor.	17 03	61 50	1835	Apr. 30.	48 46.2	6.90
Antigua, Caribbee Islands.	17 08	61 52	1848	----	49 11	----
Alta Vela, off San Domingo.	17 28	71 39	1835	Feb. 6.	47 39	6.48
Kingston (or Port Royal), Jamaica.	17 56	76 51	1822	----	46 55	----
Do.	17 56	76 51	1834	----	47 19	----
Kingston, on the point at Port Royal.	17 56	76 51	1834	July 11; Aug. 1; Sept. 30; Oct. 6.	47 01.3	7.08
Kingston.	17 57	76 49	1857	Feb. 25; Mar. 2.	46 32	7.179
Anguilla Island, Caribbee Islands.	18 14	63 05	1846	----	50 15	----
St. Thomas.	18 20	64 56	1834	----	49 29	----
Do.	18 20	64 56	1846	----	49 40	----
Do.	18 20	64 55	1857	Feb. 17.	48 30	6.723
Do.	18 20	64 55	1865	Nov. 14.	49 38	6.758
Porto Rico, San Juan.	18 29	66 10	1852	----	50 15	----
Cayman Island.	19 14	81 05	1822	----	48 48	----
Barracoa, Cuba.	20 22	74 29	1831	----	50 07	----
Cozumel.	20 33	86 57	1879	Apr. 23, 24, 25.	48 06.5	7.176
Mugeres Island.	21 14.7	86 45.7	1879	Apr. 28, 29, 30.	49 32.9	7.063
Cape San Antonio, Cuba.	21 55.5	84 55	1879	Apr. 7, 8, 9.	50 14.9	7.035
Arenas Cay.	22 07.2	91 24.9	1880	Jan. 28, 29.	49 35.8	7.103
Perez Island.	22 23.5	89 42.0	1880	Jan. 22, 23.	50 09.7	7.055
Bahia Honda, Cuba.	22 58.4	83 12	1879	Mar. 28, 29, 31.	52 18.4	6.858
Matanzas, Cuba.	23 02.9	81 36.9	1879	Mar. 6, 7, 8.	52 23.4	6.823
Havana.	23 09	82 23	1801	Jan.	53.22	6.10(?)
Do.	23 09	82 22	1822	----	51.55	----
Do.	23 09	82 22	1857	Jan. 27, 28.	52 00	6.921
Havana, Jesuit College of Belen.	23 08.2	82 21.3	1879	Mar. 13-16.	52 18.1	6.847
Water Cay, Salt Key Banks.	23 59.2	80 20.8	1879	Feb. 28.	53 41.6	6.742
Nassau, New Providence Island.	25 05	77 22	1841	----	56 13	----
Do.	25 05	77 22	1843	----	56 23	----
Nassau, New Providence, on Hog Island.	25 05.5	77 20.0	1879	Feb. 18, 19, 20.	55 50.5	6.503
South Bemini, Bahama Islands.	25 42	79 17.6	1879	Feb. 24, 25, 26.	56 20.3	6.448
Bermuda, signal station, St. George's Town.	32 23	64 42	1831	----	65 18	----
Do.	32 23	64 42	1845	Oct.	65 26.2	----
Do.	32 23	64 42	1846	----	65 24	----

*intensities in the United States and adjacent regions.—Continued.*

## WEST INDIA ISLANDS AND BERMUDAS.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1825-0}$	$H_{1825-0}$	$F_{1825-0}$		
8.98	°			E. Sabine.	Phil. Trans. R. S., 1875.
---				Foster.	Do.
9.52				K. Friesach.	Do.
---				Zahrtmann.	Do.
9.18				E. Home.	Phil. Trans. R. S., 1838.
---				Do.	Do.
---				Schomburgh.	Phil. Trans. R. S., 1875.
10.08				E. Home.	Phil. Trans. R. S., 1838.
---				Barnett.	Phil. Trans. R. S., 1875.
9.41				E. Home.	Phil. Trans. R. S., 1838.
---				E. Sabine.	Phil. Trans. R. S., 1875, Sir E. Sabine, Cont. XIV.
---				Barnett.	Do.
10.52	47.4	7.12	10.52	E. Home.	Phil. Trans. R. S., 1838.
10.436				K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858.
---	50.8			Barnett.	Phil. Trans. R. S., 1875.
---				Zahrtmann.	Phil. Trans. R. S., 1875, Sir E. Sabine, Cont. XIV.
---				Schomburgh.	Do.
10.139	49.9	6.73	10.45	K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858.
10.434				W. Harkness.	Smithsonian Cont's to Know., No. 239, Wash., 1873, Cruise of the Monadnock.
---	50.7			Norwegian officer.	Phil. Trans. R. S., 1875.
---				E. Sabine.	Do.
---				Foster.	Do.
10.75	48.2	7.15	10.73	S. M. Ackley.	C. & G. S. Rpt., 1881, App. 9.
10.89	49.6	7.03	10.85	Do.	Do.
11.00	50.3	7.01	10.98	Do.	Do.
10.96	49.7	7.08	10.95	Do.	Do.
11.01	50.2	7.03	10.98	Do.	Do.
11.22	52.4	6.83	11.19	Do.	Do.
11.18	52.5	6.80	11.17	Do.	Do.
10.23(?)				A. v. Humboldt.	Becquerel's Traité du Magnétisme, Paris, 1846; Rpt. Brit. Asso., Vol. VI, 1838; C. S. Rpt., 1861, App. 22.
11.30	52.4	6.82	11.18	E. Sabine.	Rpt. Brit. Asso., Vol. VI, 1838; C. S. Rpt., 1861, App. 22.
11.243				K. Friesach.	K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858.
11.20				S. M. Ackley.	C. & G. S. Rpt., 1881, App. 9.
11.39	53.7	6.72	11.35	Do.	Do.
---				Barnett.	Phil. Trans. R. S., 1875.
---	56.0	6.50	11.62	Do.	Do.
11.58				S. M. Ackley.	C. & G. S. Rpt., 1881, App. 9.
11.63	56.3	6.44	11.61	Do.	Do.
---				Austin and Foster.	Phil. Trans. R. S., 1875, Sir E. Sabine.
---				Barnett.	Bermuda Royal Gazette.
---				Do.	Phil. Trans. R. S., 1875, Sir E. Sabine.



TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
WEST INDIA ISLANDS AND BERMUDAS—Continued.

Name of station.	Latitude φ.	West longi- tude λ.	Year.	Month.	Dip θ.	Horizontal force H.
Bermuda, Mount Langton.	32 18. 2	64 49	1872	Nov. 5-11.	67 20. 1	----
Bermuda, Mount Langton, garden.	32 18. 2	64 49. 5	1873	Apr. 10, 11.	67 20	4. 764
Bermuda, Mount Langton, Ducking Stool.	32 18. 2	64 49	1873	June 6, 9.	66 44. 7	4. 789
Bermuda, Tatem Island.	32 17. 2	64 53. 3	1873	June 5.	67 02. 8	----
Bermuda, Somerset Island.	32 18	64 53. 5	1873	Apr. 7.	65 44. 2	5. 073
Bermuda, Spanish Point.	32 18. 2	64 50. 5	1873	Apr. 12, 17.	67 19. 8	4. 786
Bermuda, Ireland Island, cemetery spar-yard.	32 18. 7	64 52. 2	1873	Apr. 9, 12.	{ 66 27. 6 66 33. 8 }	----
Bermuda, Clarence Cove.	32 18. 8	64 50	1873	June 3, 9.	66 44	4. 914
Bermuda, in the dock-yard.	32 19	64 51.	1834	June 11, 16.	67 45	} 4. 82
Do.	32 19	64 51	1836	Feb. 6.	67 18	
Bermuda, near dock-yard.	32 19. 2	64 51. 8	1873	May 13; June 10, 12.	66 25. 8	4. 922

## MEXICO AND CENTRAL AMERICA.

Panama.	8 57	79 29	1790	Oct. 3.	29 29	----
Do.	8 57	79 29	1837	----	31 51. 9	7. 743
Do.	8 57	79 31	1858	Apr. 29; May 2.	32 30	7. 654
Do.	8 54	79 30.	1866	May 14.	31 56	7. 614
Chagres, castle of Saint Lorenzo.	9 20	80 01	1834	Sept. 18, 19.	32 30	7. 55
Nicaragua, Point Arenas.	10 58	83 43	1834	Sept. 11, 12.	34 05	7. 56
Nicaragua, or Rivas.	10 56	83 42	1839	----	34 43	---
Realejo, Nicaragua.	12 36	87 18	1791	Jan 25.	33 05	----
Do.	12 28	87 08	1838	----	34 36. 9	----
La Union, Chiquiriu Point, San Salvador.	13 17. 2	87 46. 4	1880	Nov. 1, 2.	38 23. 9	7. 284
Acajutla, San Salvador.	13 34. 1	89 50. 7	1880	Nov. 6, 7.	37 49. 7	7. 498
Port Escondido.	16 04. 1	96 56. 7	1880	Nov. 17, 18.	39 13. 2	7. 504
Salina Cruz, Tehuantepec.	16 09. 6	95 26. 7	1880	Nov. 13, 14, 15.	40 08. 5	7. 479
Acapulco, Mexico.	16 50	99 52	1791	Apr. 29.	36 07. 5	----
Do.	16 50. 5	99 53	1803	March.	38 53	----
Do.	16 50	99 55	1838	----	37 57. 4	7. 91
Do.	16 50	99 52	1866	May 30.	39. 54	7. 740
Do.	16 49. 2	99 56. 3	1880	Nov. 22, 23, 24.	40 08. 5	7. 518
Belize, British Honduras.	17 29	88 12. 3	1879	Apr. 15, 16, 18.	43 32. 3	7. 425
Coatzacoalcos, Mexico.	18 08	94 26	1880	Feb. 20, 21, 23.	43 03. 3	7. 398
Clarion Island, off Lower California.	18 21	114 41	1839	----	37 03	7. 597
Do.	18 19. 6	114 41. 9	1880	Oct. 8, 9.	39 34. 0	7. 357
Laguna de Terminos, Gulf of Campeche.	18 38	93 00	1880	Mar. 2, 3, 4.	44 18. 3	7. 353
Socorro Island, off Lower California.	18 43	110 54	1839	----	40 43. 7	7. 477
Do.	18 42. 8	110 54. 2	1880	Oct. 11, 12.	41 18. 7	7. 513

*intensities in the United States and adjacent regions.—Continued.*

## WEST INDIA ISLANDS AND BERMUDAS—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1882.0}$	$H_{1882.0}$	$F_{1882.0}$		
----	<sup>0</sup> (67.06)	(4.77)	(12.24)	J. H. Lefroy.	Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883.
12.362	----	----	----	Maclear and Sloggett.	Voy. of H. M. S. Challenger, Capt. G. S. Nares, Vol. II, London, 1882.
12.129	----	----	----	Maclear and Bromley.	Do.
----	----	----	----	Do.	Do.
12.345	----	----	----	Maclear and Sloggett.	Do.
12.417	----	----	----	Do.	Do.
----	----	----	----	Do.	Do.
12.443	----	----	----	Maclear and Bromley.	Do.
12.32	{	----	----	E. Home.	Phil. Trans. R. S., 1838, Pt. I, Capt. Sir E. Home. [Lat. and long. corrected.]
----		----	----	Do.	Do.
12.309	(66.49)	(4.91)	(12.31)	Maclear and Bromley.	Voy. of H. M. S. Challenger, Capt. G. S. Nares, Vol. II, London, 1882.

## MEXICO AND CENTRAL AMERICA.

----	{	32.9	7.514	8.95	Don A. Malaspina.	Bode's Astr. Jahrb. Berlin, 1828.				
9.123					E. Belcher.	Phil. Trans. R. S., 1843.				
9.075					R. W. Haig.	Phil. Trans. R. S., 1864.				
8.972					W. Harkness.	Smithsonian Cont's to Know., No. 239, Wash., 1873.				
9.02	{	34.0	----	----	E. Home.	Phil. Trans. R. S., 1838, pt. I.				
9.34		35.8	----	----	Do.	Do.				
----	{		----	Barnett.	Phil. Trans. R. S., 1875.					
----	{	36.0	----	----	Don A. Malaspina.	Bode's Astr. Jahrb., Berlin, 1828.				
----					{		E. Belcher.	Phil. Trans. R. S., 1843.		
9.29	38.53	7.262	9.28	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.					
9.49	37.96	7.476	9.48	Do.	Do.					
9.68	39.35	7.482	9.68	Do.	Do.					
9.78	40.27	7.457	9.77	Do.	Do.					
----	{	40.35	7.57	9.93	Don A. Malaspina.	Bode's Astr. Jahrb., Berlin, 1828.				
----					{				A. v. Humboldt (?)	Becquerel's Traité du Magnétisme, Paris, 1846.
10.03									E. Belcher.	Phil. Trans. R. S., 1843 & 1875.
10.089									W. Harkness.	Smithsonian Cont's to Know., No. 239, Wash., 1873.
9.83	{	43.7	7.395	10.23	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.				
10.24					S. M. Ackley.	Do.				
10.12					Do.	Do.				
9.52		39.73	7.335	9.54	E. Belcher.	Phil. Trans. R. S., 1843 & 1875.				
9.54	{				H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.				
10.28	44.46	7.329	10.27	S. M. Ackley.	Do.					
9.87				{				E. Belcher.	Phil. Trans. R. S., 1843 & 1875.	
10.00	41.47	7.491	10.00	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.					

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
MEXICO AND CENTRAL AMERICA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Cocolopam, Orizaba.	18 53	97 04	1856	Aug. 26, 27.	42 51	7.579
Potrero.	18 56	96 48	1856	Aug. 16, 17.	42 51	7.574
San Andres, Chalchecomula, State of Puebla.	18 59	97 15	1856	Sept. 17, 18.	42 38	7.589
Manzanilla.	19 02.8	104 20.5	1880	Nov. 30; Dec. 1.	43 15.8	7.320
Tlamacas.	19 03	98 39	1857	Jan. 25.	42 34	7.571
Vera Cruz, Villa la Guaca, south of city.	19 12	96 09	1856	Aug. 7, 8.	43 58	7.533
Vera Cruz, northeast bastion, castle of San Juan d'Ulloa.	19 12.2	96 08.5	1880	Feb. 10, 11, 12.	44 04.6	7.391
Mirador, State of Vera Cruz.	19 13	96 37	1856	Oct. 10, 11.	43 50	7.522
Chalco.	19 18	98 51	1857	Jan. 6.	43 12	7.540
Mexico, city.	19 26	99 06	1778	----	38 00	----
Do.	19 26	99 06	1799	----	42 10	----
Mexico, Convent of San Augustin.	19 26	99 05	1803	Dec.	42 10	6.69 (?)
Do.	19 26	99 05	1857	Dec. 10, 17.	41 26	7.576
Mexico, Central Observatory for Magnetism and Meteorology.	19 26	99 06.6	1879	Sept.—Dec.	44 51.7	7.480
Do.	19 26	99 06.6	1884	Apr. 5, 8, 9, 11, 19.	45 01.4	----
Campeche, Yucatan.	19 50.5	90 33.3	1880	Mar. 8, 9, 10.	46 20.7	7.229
Progreso, Yucatan.	21 16.8	89 39.5	1880	Mar. 13, 15.	48 52.3	7.090
San Blas, Mexico.	21 32	105 16	1791	Apr. 12.	43 11.2	----
Do.	21 32	105 16	1837	----	46 09	----
San Blas, Palm Island.	21 32	105 16	1837	----	45 24.3	----
San Blas, Mexico.	21 32	105 16	1838	----	44 36	----
San Blas, Beach.	21 32	105 16	1839	----	44 32.5	7.421
San Blas, Mexico.	21 32.2	105 18.1	1880	Dec. 4, 5.	46 20.8	7.204
Contoy Island.	21 32	86 49	1838	----	49 48	----
Arenas.	22 07	91 24	1847(?)	----	49 32	----
San Lucas Bay.	22 52	109 53	1839	----	45 39.3	7.259
Cape San Lucas, Lower California.	22 53.6	109 54.7	1881	Feb. 19, 20.	47 23.2	7.103
San José del Cabo, Lower California.	23 03.6	109 40.7	1873	Feb. 27, 28.	47 25.2	7.007
Mazatlan, Mexico.	23 11	106 24	1837	----	47 45	----
Do.	23 11	106 24	1839	----	46 38.5	7.214
Do.	24 11.5	106 26.6	1881	Feb. 12, 13.	48 15.8	7.049
La Paz, El Mogote, Lower California.	24 10.2	110 20.7	1881	Feb. 6, 7.	49 10.1	7.023
Pichilingue Bay, Lower California.	25 15.5	110 20.1	1881	Feb. 5.	49 48.5	6.885
Magdalena Bay, Lower California.	24 38	112 07	1837	----	50 43	----
Do.	24 38	112 07	1839	----	46 34	7.160
Do.	24 40	112 07	1866	June 9.	48 32	7.176
Do.	24 38.4	112 08.9	1873	Mar. 6, 7.	48 09.0	6.926
Do.	24 38.4	112 08.9	1881	Feb. 24.	48 18.7	7.032

*intensities in the United States and adjacent regions.—Continued.*

## MEXICO AND CENTRAL AMERICA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
----	0				
----	43.5	7.43	10.24	A. Sonntag and v. Mueller.	C. S. Rpt., 1856, p. 214 & Smithsonian Cont's to Know., Wash., 1860.
----	43.5	7.43	10.24	Do.	Do.
----	43.3	7.44	10.22	Do.	Do.
10.05	43.40	7.300	10.05	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
----	43.6	7.42	10.25	A. Sonntag and v. Mueller.	Smithsonian Cont's to Know., Wash., 1860.
----	44.25	7.367	10.28	Do.	C. S. Rpt., 1856, p. 214.
10.29				S. M. Ackley.	C. & G. S. Rpt., 1881, App. 9.
----	44.8	7.37	10.39	A. Sonntag and v. Mueller.	C. S. Rpt., 1856, p. 214 & Smithsonian Cont's to Know., Wash., 1860.
----	44.2	7.39	10.31	Do.	Smithsonian Cont's to Know., Wash., 1860.
----	45.0	7.440	10.49	Don Alzate.	Encyc. Met., London, 1848, Art. Magnetism.
----				A. v. Humboldt.	Do.
9.96				Do.	Rpt. Brit. Asso., Vol. VI, 1838, and Bequerel's <i>Traité du Magnétisme</i> , Paris, 1846. H and F very uncertain; C. S. Rpt., 1861, App. 22.
10.105				A. Sonntag and v. Mueller.	C. S. Rpt., 1856, p. 214, and Smithsonian Cont's to Know., 1860.
10.553	----	----	----	V. Reyes.	Memoria sobre el Dept. Magnetico, &c., Mexico, 1880.
----				M. Barcena.	Communication of Mexican Consul at San Francisco to Assist. G. Davidson.
10.48				S. M. Ackley.	C. & G. S. Rpt., 1881, App. 9.
10.78				----	Do.
----	46.4	7.184	10.42	Don A. Malaspina.	Bode's Astr. Jahrb., Berlin, 1828.
----				Du Petit Thouars.	Phil. Trans. R. S., 1875, Sir E. Sabine.
----				E. Belcher.	Phil. Trans. R. S., 1843 and 1875.
10.66				Do.	Phil. Trans. R. S., 1875.
----	----	----	----	Do.	Phil. Trans. R. S., 1843 and 1875.
10.43				H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
----				Barnett.	Phil. Trans. R. S., 1875.
----				Do.	Do.
10.63	47.5	7.083	10.48	E. Belcher.	Phil. Trans. R. S., 1843 and 1875.
10.49				H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
10.36	47.5	6.95	10.29	W. Eimbeck and G. Davidson.	Do.
----	48.38	7.029	10.58	Du Petit Thouars.	Phil. Trans. R. S., 1875.
10.75				E. Belcher.	Phil. Trans. R. S., 1843 and 1875.
10.59				H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
10.74	49.29	7.003	10.74	Do.	Do.
10.67	49.93	6.865	10.66	Do.	Do.
----	48.44	6.99	10.54	Du Petit Thouars.	Phil. Trans. R. S., 1875.
10.75				E. Belcher.	Phil. Trans. R. S., 1843 and 1875.
10.837				W. Harkness.	Smithsonian Cont's to Know., No. 239, Wash., 1873.
10.38				W. Eimbeck and G. Davidson.	C. & G. S. Rpt., 1881, App. 9.
10.57	----	----	----	H. E. Nichols.	Do.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
MEXICO AND CENTRAL AMERICA—Continued.

Name of station.	Latitude $\phi$ .	West longi- tude $\lambda$ .	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Isle San Josef, Lower California.	24 55.0	119 37.3	1881	Jan. 31; Feb. 1.	49 38.5	6.838
Loreto, Lower California.	26 01.1	111 20.5	1881	Jan. 27, 28.	51 00.8	6.789
Pequeña Bay, Lower California.	26 15.9	112 28.5	1881	Feb. 28.	51 48.1	6.689
Santa Barbara Bay, Mexico.	26 41.5	109 38.4	1880	Dec. 22, 23.	52 21.2	6.735
Point Abrejos, Lower Cal.	26 47.0	113 31.2	1881	Mar. 2, 3.	51 47.7	6.705
Mulege, Lower Cal.	26 53.8	111 58.2	1881	Jan. 24, 25.	52 05.5	6.724
Ascension Island.	27 06.0	114 18.4	1881	Mar. 4, 5.	51 43.4	6.710
Santa Maria Cove, Lower Cal.	27 25.2	112 19.5	1881	Jan. 19, 20.	52 56.8	6.681
Saint Bartholomew.	27 39.6	114 53	1839	----	51 41	6.780
Guaymas, Mexico.	27 54.8	110 52.6	1880	Dec. 27, 28.	52 58.0	6.619
Cerros Island, Lower Cal.	28 03.9	115 11.5	1873	Feb. 17.	52 30.5?	6.505
Do.	28 03.4	115 11.3	1881	Mar. 7, 8.	52 55.0	6.603
Santa Teresa Bay, Lower Cal.	28 25.1	112 51.9	1881	Jan. 17, 18.	53 49.0	6.571
Guadalupe Island, Lower Cal.	28 55.3	118 15.1	1881	Mar. 18.	53 38.9	6.421
Tiburon Island, Mexico.	29 11.5	112 27.0	1880-81	Dec. 31; Jan. 1.	54 59.2	6.477
Presidio del Norte, Rio Grande.	29 34	104 25	1852	----	55 41	----
San Geronimo Island, Lower Cal.	29 47.2	115 47.7	1881	Mar. 23, 25.	54 30.0	6.430
San Luis Gonzales, Lower Cal.	29 50.9	114 25.4	1881	Jan. 14, 15.	55 11.3	6.425
San Quentin.	30 22	115 58	1839	----	54 29.9	6.468
San Martin Island, Lower Cal.	30 29.4	116 07.2	1881	Mar. 29, 30.	55 34.4	6.377
Point San Felipe, Lower Cal.	31 02.1	114 49.8	1881	Jan. 12, 13.	56 25.2	6.272
Rocky Point, Mexico.	31 17.2	113 33.1	1881	Jan. 4, 5.	57 14.7	6.250
Espia.	31 21	107 56	1855	Mar. 22.	57 59	6.242
Philipps' Point, Mexico.	31 46.1	114 43.4	1881	Jan. 8, 9, 10.	57 31.8	6.184
Todos Santos, Lower Cal.	31 51.4	116 37.6	1881	Apr. 2, 3.	58 30.6	6.044

## EASTERN SIBERIA.

Name of station.	Latitude $\phi$ .	Longitude $\lambda$ .*	Year.	Month.	Dip $\theta$ .	Horizontal force H.
Petropavlovsk, Kamchatka.	53 01	158 43	1779	June and Sept.	63 05	----
Do.	53 01	158 43	1804	Sept.	63 32	----
Do.	53 00	158 43.5	1827	July.	64 02	----
Do.	53 00	158 40	1827	Sept. 30.	64 07	----
Do.	53 00	158 40	1829	Oct. 13.	63 49	----
Do.	53 01	158 43	1837	Sept. 4 and 5.	64 05	----
Do.	53 00	158 43	1854	July.	64 47	----
Do.	53 00.6	158 39.2	1876	June 12; Sept. 15.	64 14	----

\*A — sign indicates west longitude; + sign indicates east longitude from Greenwich.

*intensities in the United States and adjacent regions.—Continued.*

## MEXICO AND CENTRAL AMERICA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
10. 56	49. 75	6. 819	10. 55	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
10. 79	51. 12	6. 770	10. 79	Do.	Do.
10. 82	51. 91	6. 671	10. 81	Do.	Do.
11. 03	52. 47	6. 714	11. 02	Do.	Do.
10. 84	51. 86	6. 688	10. 83	Do.	Do.
10. 94	52. 16	6. 707	10. 93	Do.	Do.
10. 83	51. 79	6. 693	10. 82	Do.	Do.
11. 09	53. 02	6. 664	11. 08	Do.	Do.
11. 20	53. 0	----	----	E. Belcher.	Phil. Trans. R. S., 1843 and 1875.
10. 99	52. 97	6. 601	10. 96	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
10. 69	52. 95	6. 586	10. 93	W. Eimbeck and G. Davidson.	Do.
10. 95				H. E. Nichols.	Do.
11. 13	53. 82	6. 554	11. 10	Do.	Do.
10. 83	53. 72	6. 404	10. 82	Do.	Do.
11. 29	55. 08	6. 459	11. 28	Do.	Do.
----	55. 6	----	----	W. H. Emory.	U. S. & Mex. Bound. Sur., Am. Acad. Sc., Vol. VI, 1856.
11. 07	54. 50	6. 413	11. 04	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
11. 25	55. 19	6. 408	11. 23	Do.	Do.
11. 41	----	----	----	E. Belcher.	Phil. Trans. R. S., 1843 and 1875.
11. 28	55. 58	6. 360	11. 25	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
11. 31	56. 42	6. 255	11. 31	Do.	o.
11. 55	57. 24	6. 233	11. 52	Do.	Do.
11. 77	57. 9	6. 11	11. 50	W. H. Emory.	U. S. & Mex. Bound. Sur., Am. Acad. Sc., Vol. VI, 1856.
11. 52	57. 53	6. 168	11. 49	H. E. Nichols.	C. & G. S. Rpt., 1881, App. 9.
11. 57	58. 51	6. 028	11. 54	Do.	Do.

## EASTERN SIBERIA.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
	°				
----	64. 0	-----	-----	J. King.	Voyage to the Pacific, London, 1784.
----				A. J. v. Krusenstern.	Do.
----				F. W. Beechey.	Voyage to the Pacific, 1825-28, London, 1831.
----				F. P. Lütke.	Mémoires St. Petersburg Acad., 1838.
11. 25				Ad. Erman.	Reise um die Erde, Berlin, 1835. Value of F deduced by M. Baker = 11.10.
11. 11				Du Petit Thouars.	Voyage autour du Monde, Paris, 1843. Value of F deduced by M. Baker.
----				----	Frigate Aurora.
----				M. L. Onazevich.	Russian publication, communicated by M. Baker.

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*  
EASTERN SIBERIA—Continued.

Name of station.	Latitude φ.	Longitude λ.*	Year.	Month.	Dip θ.	Horizontal force H.
Natschika.	53 07	157 25	1829	----	64 05	----
Bering Island.	55 14	165 52	1879	Aug.	66 35	4. 539
St. Lawrence Island.	63 43	—171 23	1879	Aug.	74 25	3. 327
Plover Bay, Port Providence.	64 26	—173 15	1849	----	75 10	----
Do.	64 22. 4	—173 21. 5	1869	Aug. 3, 5.	74 38. 8	----
Do.	64 22	—173 21. 5	1876	July 21 <sup>st</sup> -27.	74 55	----
Do.	64 22. 0	—173 21. 5	1880	Aug. 12; Sept. 13.	74 46. 4	3. 262
Ongayak.	64 24	—172 20	1849	----	75 25	----
Konyam Bay.	64 50	—172 57	1879	July.	75 10	3. 195
Holy Cross Bay.	65 28	—178 32	1828	----	75 43	----
Yandangah.	65 29	—170 50	1849	----	76 17	----
Laurenne.	65 32	—171 40	1849	----	77 15	----
St. Lawrence Bay.	65 35	—170 44	1879	July.	75 55	3. 078
Do.	65 38	—170 46	1828	----	76 36	----
Do.	65 37	—170 40	1849	----	76 37	----
Big Diomedé Island.	65 44. 9	—169 04. 4	1880	Sept. 10.	76 15. 0	2. 981
Chagneen.	65 45	—170 30	1849	----	76 56	----
Pitlekai.	67 05	—173 30	1878	Sept.	76 59	2. 887
Do.	67 04	—173 30	1878-9	Winter.	77 01	2. 861
Irkaipi.	68 49	180 00	1878	Sept.	77 56	2. 676
Werkon River.	69 53	173 32	1823	----	79 59	----
Wrangell Land, Rodgers' Harbor.	70 57	—178 10	1881	Sept.	79 15	----
Wrangell Land, Hooper's Cairn, east coast.	71 04	—177 40	1881	Aug. 12.	79 52. 5	----

\*A — sign indicates west longitude; a + sign indicates east longitude from Greenwich.

*intensities in the United States and adjacent regions.—Continued.*

## EASTERN SIBERIA—Continued.

Total force F.	Referred results.			Observer.	Reference and remarks.
	$\theta_{1885.0}$	$H_{1885.0}$	$F_{1885.0}$		
11.45	°	----	----	Ad. Erman.	Phil. Trans. R. S., 1872.
----	66.5	4.54	11.39	A. Wijkander.	L'expédition de la Vega, 1878-80, Stockholm, 1883.
----	74.3	3.33	12.31	Do.	Do.
----	74.7	3.26	12.35	Moore.	Phil. Trans. R. S., 1872.
12.12				A. Hall.	Rpt. Sol. Eclipse, 1869, U. S. Nav. Obsy., Wash.
----				M. L. Onazevich.	Russian publication, commun'd by M. Baker.
12.42				W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
----	----	----	----	Moore.	Phil. Trans. R. S., 1872.
----	75.1	3.20	12.44	A. Wijkander.	L'expédition de la Vega, 1878-80, Stockholm, 1883.
12.80	----	----	----	F. P. Lütke.	Phil. Trans. R. S., 1872.
----	----	----	----	Moore.	Do.
----	----	----	----	Do.	Do.
----	75.8	3.08	12.56	A. Wijkander.	L'expédition de la Vega, 1878-80, Stockholm, 1883.
12.84				F. P. Lütke.	Phil. Trans. R. S., 1872.
----				Moore.	Do.
12.54	76.2	2.98	12.49	W. H. Dall and M. Baker.	C. & G. S. Rpt., 1881, App. 9.
----	----	----	----	Moore.	Phil. Trans. R. S., 1872.
----	76.9	2.87	12.66	A. Wijkander.	L'expédition de la Vega, 1878-80, Stockholm, 1883.
----				Do.	Do.
----	77.8	2.68	12.68	Do.	Do.
----	----	----	----	Wrangell.	Phil. Trans. R. S., 1872.
----	79.2	----	----	Putnam.	----
----	79.8	----	----	C. L. Hooper.	Paper read before Geog. Soc., San Francisco, by Geo. Davidson, Dec., 1881.



## PART II.

## SECULAR VARIATION OF THE MAGNETIC DIP IN THE UNITED STATES.

At the time of the appearance of Appendices Nos. 32 and 33, Coast Survey Report for the year 1856, which contain a first discussion, by the writer, of observed dips, the facts known respecting the secular variation of the dip within the limits of the United States were very meager and in part conjectural. Prof. E. Loomis appears to have been the first to give attention to the subject. He remarks (Silliman's Journal, 1838), "From the course of the observations made in other places by Professor Bache it may be inferred that the dip in 1834 was at Cambridge  $73^{\circ} 33'$ , being an increase since 1783 of  $3^{\circ} 52'$ , or about  $4\frac{1}{2}'$  per year. It may be considered as established that the dip has increased in this country since the earliest observations, but whether it is still increasing at the present time seems more uncertain."

"The observations made at Albany and New York may excite a suspicion that such is not the fact. It is hoped that so important a question will not long remain doubtful."

It may be remarked to this that the supposed increase in the dip must probably be referred back to the first quarter or earlier part of the present century, and that the Cambridge observations of 1780-'83 are looked upon with doubt as to their reliability; at any rate they cannot be reconciled with our present knowledge of the secular change. It is true they were formerly supposed the earliest known recorded dips in the country, a distinction which now must be accorded, however, to Unalashka (1778), but there were no other observations on or near our Atlantic coast till 1822, thus cutting off the means of comparison and verification. In his second collection of dips (Silliman's Journal, 1840), Professor Loomis arrives at more certain results by comparing Long's dips of 1819 with others of 1839, where he notices a difference of  $30'$ , and says, "In the absence, then, of more accurate data we may call this the diminution of the dip from 1819 to 1839, being at the rate of  $1.5'$  per year." Again, comparing the dips in New York by Sir E. Sabine and Sir J. Franklin (1822 to 1825) with his own and others about the epoch 1835, he finds a difference of  $25'$  and concludes a diminution of  $2.1'$  per annum and assumes the mean between the two determinations, or  $1.8'$ , to be the annual diminution of the dip for the (Eastern) United States.

Taking up the subject in 1856, I showed that in the Northeastern part of the country the dip continued to decrease till about the year 1843, when the dip became stationary; the occurrence of this minimum was fixed at  $1842.7 \pm 0.7$ , and it was further shown that since the reversal of the motion at that epoch the dip had already attained, in 1856, an average annual increase of  $2.7'$ , and it was conjectured that the formulæ given for the secular variation would apply for ten or fifteen years after this minimum epoch. Subsequent observations, however, did not verify this range of applicability, as we shall presently see. This increase of the dip became first apparent at the magnetic observatory at Toronto, Canada, and Colonel Sabine remarks (Vol. II of the Toronto Observations, London, 1853): "On a first inspection of the values of the inclination in the years from 1841 to 1852, inclusive, we might be led to infer that in 1843 or 1844 the secular change at Toronto reached a turning epoch, and that from having been previously a decrease it became subsequently an increase of inclination. It is possible, however, that the facts may admit, and may hereafter receive, a different explanation." In the year 1855 Prof. Chr. Hansteen published three articles in the *Astronomische Nachrichten* (Nos. 947, 948, and 954) "On the variations of the magnetic inclination in the northern temperate zone." To these papers reference was made by me in 1856, since they include the two stations, New York and Sitka. For the former place the analytical formula produces a maximum for  $1822.3 \pm 1.1$ ; I am, however, inclined to think that this maximum happened earlier. For the latter place his formula gives a minimum in  $1838.8 \pm 6.4$ , but I think there is little probability that this has any relation to the minimum noticed at stations in the Eastern section of the country.

Coming now to later researches, the occurrence of this minimum about 1840 to 1844 was certainly as unexpected as subsequently the sudden stoppage of the increasing dip about 1859 in the Eastern part of the United States. Reasoning by analogy from what we knew of the long period of the secular variation in the declination and the long continued variation in the dip at certain stations, tho' not within our geographical limits, it was reasonable to expect that the increase in

the dip would continue to be observed at least for many years. This idea, however, was quickly dispelled and since about 1860 the dip in nearly all parts of the United States has again resumed the direction of diminishing value, thus suggesting the idea of a *secondary* motion or wave of comparatively short duration and of a character opposite to the general motion in the variation of the dip, as it existed before and after this temporary interruption. The observations made at Washington (see Coast Survey Report for 1870, Appendix No. 14) first indicated, in 1860, a change in the sign of the annual progression, which change was soon confirmed by the observations at Eastport, Me., at Key West, Fla., and at Toronto, Canada. At Washington and Toronto the former annual increase ceased about 1859, and the annual decrease, which soon after set in, seems to have rapidly spread over the whole country, though apparently it only reached Southern California at a much later time. *An annual diminution is now the rule* and it applies also to Canada and a part of the British North American Possessions; thus at Lake Athabasca, Sir J. H. Lefroy remarks in his "Diary of a Magnetic Survey of a Portion of the Dominion of Canada, chiefly in the Northwestern Territories, etc." (London, 1883): "If we may assume that this element (the dip) attained its maximum value at Lake Athabasca at the same epoch as it did at Toronto (1859) it was probably again the same in 1874 as it was in 1844, and we have, therefore, for the present rate of secular change of dip in that quarter  $-1.7$  per annum."

When we enter more minutely into the investigation of the law of secular change we find the same to be dependent, as in the case of the change in declination, on the latitude and longitude of the place, and it will be desirable to divide the total geographical area into separate areas possessing a similar characteristic with respect to the secular variation. An examination of the figures of Table II (given further on) which were extracted from the general Table I, will show the difficulty in recognizing the true law of change in consequence of obscuration by defective values, due either to indifferent observations, to defective needles, or more generally to local effects from change of place. To overcome this difficulty the dips at the various places and included in a certain region were plotted on the same scale and for the same time ordinates, by which means it became possible to recognize any common feature as well as any defective observation, yet considerable difficulties were encountered in understanding and extracting the law from scanty, conflicting, or otherwise confusing data, as those, for instance, in the West Indies and California. With but a very few exceptions we have to contend with an insufficient number of observations as well as with a want of equal distribution in time, even over the short period at present at our command, nor can we feel quite sure of having seized the correct interpretation in all cases.

We shall first give in tabular form, and conveniently arranged for computation, the observed dips at leading stations, selected from those of Table I in consequence of their fitness for the investigation of the secular variation or of the present annual change. For some of these stations the dips have also been expressed by means of an exponential function (as had been done in 1856). Such expressions apply only for a very limited time but they will enable us to refer observations to any desired epoch, within their proper range of applicability, for which it may be intended to chart the isoclinics. In establishing these equations for dip we have used the method of least squares, and had also resort to otherwise interpolated values to fill up gaps in time or defects in extent of series, thus simply trying to make the best of imperfect material.

The formulæ involved may be briefly recapitulated as follows:

Let  $\theta$  = the dip at any time  $t$  where  $t$  is expressed in years and fractions of a year. It is considered positive when the north end of the needle dips below the horizontal plane.

$\theta_0$  = the dip corresponding to the time  $t_0$  for which epoch the year 1850 has been adopted in conformity with the paper in the Coast and Geodetic Survey Report for 1882, Appendix No. 12, containing the discussion of the secular variation of the magnetic declination. We put

$$\theta = \theta_0 + y(t - t_0) + z(t - t_0)^2 + u(t - t_0)^3 + \dots$$

or

$$\theta = \theta_1 + x + y \cdot \Delta t + z \cdot \Delta t^2 + u \cdot \Delta t^3 + \dots$$

where  $\Delta t = t - 1850.0$  and  $\theta_1$  and assumed value of  $\theta_0$  and  $x, y, z, u$  the correction and the factors to be determined from the observations themselves.

H. Ex. 18—23

Each observation will furnish an equation of condition of the form

$$0 = \theta_1 - \theta + x + y \cdot \Delta t + z \cdot \Delta t^2 + u \cdot \Delta t^3$$

stopping at terms involving the third power of the time. To facilitate the solution of the normal equations we introduce the quantities

$$X = x \qquad Y = 10y \qquad Z = 10^2z \qquad U = 10^3u$$

and multiply the first equation by  $10^0$ , the second by  $10^1$ , the third by  $10^2$ , and the fourth by  $10^3$ .

We also have:

$$\frac{d\theta}{dt} = y + 2z(t - t_0) + 3u(t - t_0)^2$$

hence the annual change

$$a = y + 2z \cdot \Delta t + 3u \cdot \Delta t^2$$

For condition of maximum or minimum, and for point of inflection we have

$$0 = y + 2z(t - t_0) + 3u(t - t_0)^2$$

$$\frac{d^2\theta}{dt^2} = 0 = 2z + 6u(t - t_0)$$

The time of maximum annual change is given by  $T_{11} = t_0 - \frac{z}{3u}$  and the times of maximum and of minimum dip by :

$$T = t_0 - \frac{z}{3u} + \sqrt{\left(\frac{z}{3u}\right)^2 - \frac{y}{3u}} \qquad T_1 = t_0 - \frac{z}{3u} - \sqrt{\left(\frac{z}{3u}\right)^2 - \frac{y}{3u}}$$

The probable error  $\epsilon_0$  of a single value is found by

$$\epsilon_0 = 0.674 \sqrt{\frac{z \cdot \Delta^2}{n-4}}$$

The numerical application of the formulæ was only extended to a few selected stations which more or less admitted of it; the results follow the columns of tabular values and of observers.

TABLE II.—Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.

No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.	No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.
	<i>Halifax, Nova Scotia.</i>		°	°	°		<i>Montreal, Canada—</i> <i>Cont'd.</i>		°	°	°
1	Home.	1834.4	75.55			4	Lefroy.	1843.3	77.15		
2	Home.	1837.4	74.97			5	Younghusband.	1845.5	77.14		
3	Estcourt.	1838.5	74.75			6	Schott.	1859.5	76.86		
4	Keely.	1847.5	75.62			7	Baylor.	1879.7	76.43		
5	Maclear and Bromley.	1873.4	74.80				<i>Cambridge and Boston,</i> <i>Mass.</i>				
6	Baylor.	1879.7	74.65				Williams.	1780.9	69.85 (?)		
7	Very.	1881.8	74.48				Williams.	1782.4	69.68 (?)		
	<i>Quebec, Canada.</i>						Williams.	1783.9	69.68 (?)		
1	Lefroy.	1842.7	77.26			1	Loomis and Bond.	1839.7	74.31	74.25	+ .06
2	Younghusband.	1845.5	77.15			2	Lovering and Bond.	1840.5	74.36	74.26	+ .10
3	Schott.	1859.5	77.29			3	Graham and Bond.	1841.5	74.22	74.26	— .04
4	Baylor.	1879.7	76.75			4	Locke, Lefroy, and Graham.	1842.5	74.24	74.27	— .03
	<i>Montreal, Canada.</i>					5	Graham.	1844.9	74.30	74.29	+ .01
1	Back.	1833.5	77.10			6	Locke.	1845.4	74.32	74.30	+ .02
2	Estcourt.	1838.5	76.32			7	Lee and Fauntleroy.	1846.7	74.21	74.31	— .10
3	Lefroy.	1842.7	77.22			8	Ives and Whipple.	1850.6	74.57	74.36	+ .21

TABLE II.—Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.—Continued.

No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.	No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.
<i>Cambridge and Boston, Mass.—Cont'd.</i>						<i>New York, N. Y.—Cont'd.</i>					
9	Ives and Whipple.	1854.4	74.55	74.40	+ .15	12	Kane and Sonntag.	1853.4	72.93	72.77	+ .16
10	Schott.	1855.6	74.49	74.41	+ .08	13	Schott.	1855.6	72.83	72.78	+ .05
11	Friesach.	1856.5	74.20	74.41	— .21	14	Scott and Goodfellow.	1872.8	72.60	72.64	— .04
12	Smith (W. P.).	1859.2	74.33	74.42	— .09	<i>Sandy Hook, N. J.</i>					
	Scott and Goodfellow.	1872.8	73.52 (?)	74.14	— .62	1	Renwick.	1844.6	72.63		
13	Baylor.	1879.6	73.81	73.69	+ .12	2	Schott.	1855.6	72.87		
<i>Providence, R. I.</i>						3	Hilgard (T. C.).	1873.8	72.49		
1	Bache.	1834.6	74.05			4	Baylor.	1879.5	72.14		
2	Loomis.	1839.7	73.99			<i>Philadelphia, Pa.</i>					
3	Bache.	1841.5	74.03			1	Bache and Courtenay.	1834.5	72.00	72.03	— .03
4	Lefroy.	1842.7	74.00			2	Bache.	1838.5	71.73	72.00	— .27
5	Schott.	1855.6	74.26			3	Loomis.	1839.7	72.12	71.99	+ .13
6	Sherman.	1884.5	73.28			4	Bache.	1840.7	71.88	71.99	— .11
7	Baylor.	1885.3	73.18			5	Graham, Bache, and Locke.	1841.6	71.98	72.00	— .02
<i>New Haven, Conn.</i>						6	Bache, Graham, Locke, and Lefroy.	1842.5	72.00	72.00	.00
1	Loomis.	1839.7	73.44	73.48	— .04	7	Bache.	1843.6	71.97	72.01	— .04
2	Locke and Lefroy.	1842.5	73.48	73.49	— .01	8	Bache, Locke, and Graham.	1844.3	71.99	72.01	— .02
3	Renwick.	1844.7	73.49	73.51	— .11	9	Locke.	1846.4	72.02	72.03	— .01
	Fauntleroy.	1847.8	74.28 (?)	73.54	+ .74	10	Schott.	1855.7	72.29	72.16	+ .13
4	Ruth.	1848.6	73.54	73.54	.00	11	Schott.	1862.6	72.10	72.21	— .11
5	Schott.	1855.6	73.74	73.61	+ .13	12	Scott and Goodfellow.	1872.8	72.26	72.09	+ .17
7	Thorpe.	1878.5	73.09	73.20	— .11	13	Baylor.	1877.8	71.69	71.90	— .21
8	Sherman.	1884.5	72.83	72.79	+ .04	14	Smith (E.).	1884.7	71.48	71.41	+ .07
9	Sherman.	1885.3	72.79	72.70	+ .09	<i>Baltimore, Md.</i>					
<i>Albany and Greenbush, N. Y.</i>						1	Courtenay.	1834.5	71.98	71.94	+ .04
1	Henry and Cram.	1833.3	74.85	74.76	+ .09	2	Loomis.	1839.7	71.84	71.75	+ .09
2	Bache.	1834.6	74.67	74.75	— .08	3	Bache.	1840.6	71.57	71.73	— .16
3	Loomis.	1839.7	74.85	74.75	+ .10	4	Locke, Nicollet, and Graham.	1841.6	71.70	71.71	— .01
4	Nicollet and Bache.	1841.6	74.67	74.76	— .09	5	Graham and Lefroy.	1842.7	71.69	71.68	+ .01
5	Lefroy.	1842.8	74.74	74.77	— .03	6	Graham.	1844.5	71.60	71.67	— .07
6	Locke.	1844.4	74.69	74.79	— .10	7	Schott.	1856.7	71.76	71.71	+ .05
7	Schott.	1855.6	75.18	74.97	+ .21	8	Baylor.	1877.8	71.61	71.58	+ .03
8	Friesach.	1856.7	74.93	74.98	— .05	<i>Washington and District of Columbia.</i>					
9	Dean.	1858.4	74.93	75.00	— .07	1	Wilkes.	1838.5	71.22	71.39	— .17
10	Baylor.	1879.8	74.32	74.48	— .16	2	Wilkes and Loomis.	1839.4	71.32	71.39	— .07
<i>West Point and Cold-Spring, N. Y.</i>						3	Gilliss.	1840.5	71.34	71.39	— .05
1	Courtenay and Henry.	1833.3	73.43			4	Gilliss, Bache, Nicollet, and Graham.	1841.5	71.29	71.39	— .10
2	Courtenay.	1834.5	73.62			5	Graham and Lefroy.	1842.8	71.22	71.39	— .17
3	Loomis.	1839.7	73.46			6	Locke and Graham.	1844.3	71.36	71.39	— .03
4	Graham.	1840.6	73.34			7	Lee (T. J.).	1845.4	71.57	71.39	+ .18
5	Lefroy and Bartlett.	1842.8	73.52			8	Dean and Bache.	1851.4	71.32	71.38	— .06
6	Bache.	1843.5	73.20			9	Hilgard (J. E.).	1852.4	71.27	71.37	— .10
7	Schott.	1855.7	73.91			10	Gilliss.	1853.4	71.36	71.37	— .01
<i>New York, N. Y.</i>						11	Schott.	1855.6	71.47	71.36	+ .11
1	Sabine.	1822.9	73.01	73.39	— .38	12	Schott.	1856.6	71.34	71.35	— .01
2	Franklin.	1825.2	73.45	73.23	+ .22	13	Reed.	1857.2	71.38	71.34	+ .04
3	Joslyn.	1831.3	73.00	72.93	+ .07	14	Schott.	1858.4	71.38	71.34	+ .04
4	Bach.	1833.3	73.03	72.87	+ .16	15	Schott.	1859.5	71.41	71.32	+ .09
5	Bache.	1834.6	72.86	72.84	+ .02	16	Schott.	1860.7	71.27	71.31	— .04
6	Loomis.	1839.7	72.87	72.75	+ .12	17	Walker.	1861.5	71.30	71.30	.00
7	Locke and Bache.	1841.5	72.59	72.74	— .15	18	Schott.	1862.6	71.31	71.29	+ .02
8	Lefroy and Locke.	1842.7	72.61	72.74	— .13	19	Schott.	1863.6	71.24	71.27	— .03
9	Renwick, Graham, Lefroy, and Locke.	1844.5	72.67	72.73	— .06	20	Schott.	1865.5	71.20	71.24	— .04
10	Renwick.	1845.7	72.68	72.73	— .05	21	Schott, Goodfellow, and Harkness.	1867.5	71.14	71.20	— .06
11	Locke and Norwegian officer.	1846.6	72.66	72.73	— .07						

TABLE II.—Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.—Continued.

No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.	No	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.
Washington and District of Columbia—Cont'd.						Toronto, Canada—Cont'd.					
22	Schott.	1868.5	71.06	71.18	— .12	28	Kingston.	1868.5	75.33	75.37	— .04
23	Schott and Hall.	1869.4	70.99	71.16	— .17	29	Kingston.	1869.5	.28	.36	— .08
24	Schott.	1870.5	70.92	71.13	— .21	30	Kingston.	1870.5	.27	.34	— .07
25	Schott.	1871.5	71.00	71.11	— .11	31	Kingston.	1871.5	75.28	75.30	— .02
26	Schott.	1872.5	71.01	71.08	— .07	32	Carpmael.	1885.3	74.87	74.84	+ .03
27	Schott.	1873.5	70.97	71.05	— .08	Cleveland, Ohio.					
28	Schott.	1874.5	70.88	71.02	— .14	1	Loomis.	1839.4	73.43	73.22	+ .21
29	Schott.	1875.5	70.85	70.98	— .13	2	Loomis.	1840.5	73.24	73.21	+ .03
30	Schott.	1876.3	70.79	70.95	— .16	3	Loomis.	1841.6	73.07	73.20	— .13
31	Schott.	1877.5	70.82	70.91	— .09	4	Younghusband.	1842.8	73.06	73.20	— .14
32	Schott and Thorpe.	1878.6	70.80	70.86	— .06	5	Locke.	1843.6	73.13	73.20	— .07
33	Eimbeck and Schott.	1879.5	70.81	70.82	— .01	6	Smith (W. P.).	1859.5	73.33	73.27	+ .06
34	Baylor.	1880.5	70.75	70.78	— .03	7	Goodfellow.	1871.8	73.16	73.25	— .09
35	Very.	1881.7	70.71	70.72	— .01	8	Lee (A. N.).	1872.5	73.12	73.23	— .11
36	Eimbeck and Colonna.	1882.6	70.76	70.68	+ .08	9	Lee (A. N.).	1873.5	73.13	73.22	— .09
37	Schott.	1883.5	70.68	70.63	+ .05	10	Baylor.	1880.5	73.04	73.01	+ .03
38	Maxfield, Eimbeck, and Schott.	1884.2	70.62	70.59	+ .03	Detroit, Mich.					
39	Schott.	1885.5	70.55	70.52	+ .03	1	Loomis.	1839.4	73.71	73.61	+ .10
Pittsburg and Allegheny, Pa.						2	Loomis and Nicollet.	1841.7	73.57	73.60	— .03
1	Long.	1819.3	73.20			3	Younghusband.	1842.8	73.48	73.60	— .12
2	Loomis.	1839.7	72.65			4	Locke.	1843.4	73.54	73.60	— .06
3	Bache.	1840.6	72.54			5	Lefroy.	1845.5	73.65	73.61	+ .04
4	Locke.	1841.2	72.72			6	Smith (W. P.).	1859.3	73.68	73.68	.00
5	Locke.	1842.3	72.72			7	Smith (W. P.).	1860.4	73.72	73.69	+ .03
6	Locke.	1845.3	72.78			8	Lee (A. N.).	1872.4	73.58	73.64	— .06
7	Thorpe.	1878.7	72.12			9	Lee (A. N.).	1873.4	73.57	73.63	— .06
Toronto, Canada.						10	Bailey.	1876.4	73.57	73.57	.00
1	Riddell and Younghusband.	1841.5	75.28	75.27	+ .01	Cincinnati, Ohio.					
2	Younghusband and Lefroy.	1842.5	.27	.28	— .01	1	Locke.	1838.2	70.62		
3	Younghusband and Bache.	1843.5	.24	.28	— .04	2	Locke.	1840.7	70.47		
4	Younghusband, Lefroy, and Locke.	1844.5	.25	.28	— .03	3	Locke and Loomis.	1841.6	70.45		
5	Lefroy.	1845.5	.26	.29	— .03	4	Locke.	1842.2	70.42		
6	Lefroy.	1846.5	.25	.29	— .04	5	Locke.	1843.6	70.42		
7	Lefroy.	1847.5	.26	.30	— .04	6	Locke.	1844.4	70.44		
8	Lefroy.	1848.5	.30	.31	— .01	7	Locke.	1845.3	70.43		
9	Lefroy.	1849.5	.31	.32	— .01	8	Lefroy.	1849.4	70.48		
10	Lefroy.	1850.5	.33	.32	+ .01	9	Baylor.	1880.9	70.41		
11	Lefroy.	1851.5	.34	.33	+ .01	Madison, Wis.					
12	Lefroy.	1852.5	.34	.34	.00	1	Locke.	1839.8	74.06		
13	Lefroy and Kingston.	1853.5	.37	.35	+ .02	2	Loomis.	1841.7	74.11		
14	Kingston.	1854.5	.38	.36	+ .02	3	Hilgard (F. E.).	1876.8	73.91		
15	Kingston.	1855.5	.39	.36	+ .03	4	Braid.	1877.7	73.92		
16	Kingston.	1856.5	.40	.37	+ .03	5	Suess and Baylor.	1878.8	73.93		
17	Kingston.	1857.5	.40	.38	+ .02	6	Mason.	1879.7	73.84		
18	Kingston.	1858.5	.41	.38	+ .03	7	Mason.	1880.7	73.78		
19	Kingston and Smith (W. P.).	1859.5	.42	.39	+ .04	8	Suess.	1881.9	73.80		
20	Kingston.	1860.5	.41	.39	+ .02	Saint Louis, Mo.					
21	Kingston.	1861.5	.40	.40	.00	Long.	1819.5	70.50(?)	69.99	+ .51	
22	Kingston.	1862.5	.39	.40	— .01	1	Nicollet.	1836.0	69.17	69.47	— .30
23	Kingston.	1863.5	.36	.40	— .04	2	Locke.	1839.7	69.52	69.46	+ .06
24	Kingston.	1864.5	.35	.40	— .05	3	Loomis and Nicollet.	1841.7	69.44	69.47	— .03
25	Kingston.	1865.5	.35	.39	— .04	4	Friesach.	1856.8	68.02(?)	69.64	— 1.62
26	Kingston.	1866.5	.32	.39	— .07	5	Hilgard (T. C.).	1872.5	69.57	69.56	+ .01
27	Kingston.	1867.5	.31	.38	— .07	5	Nipher.	1878.4	69.31	69.34	— .03
						Nassau, New Providence Island.					
						1	Barnett.	1841.5	56.22		
						2	Barnett.	1843.5	56.38		
						3	Ackley.	1879.1	55.84		

TABLE II.—Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.—Continued.

No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.	No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.
	<i>Havana, Cuba.</i>		°	°	°		<i>Santa Barbara, Cal.</i>		°	°	°
	Humboldt.	1801.0	53.37(?)				Douglas.	1831.4	60.80(?)		
1	Sabine.	1822.5	51.92			1	Belcher.	1839.5	58.90		
2	Friesach.	1857.1	52.00			2	Davidson and Throckmorton.	1869.9	59.27		
3	Ackley.	1879.2	52.30			3	Nichols.	1881.3	59.32		
	<i>Saint Thomas, West Indies.</i>						<i>Monterey, Cal.</i>				
1	Zahrtmann.	1834.5	49.48			1	Malaspina.	1791.7	60.94		
2	Scoomburgh.	1846.5	49.67				Vancouver.	1792.9	63.01(?)		
3	Friesach.	1857.1	48.50				Vancouver.	1794.9	63.00(?)		
4	Harkness.	1865.9	49.63				Golovnin.	1818.7	64.25(?)		
	<i>Panama, United States of Columbia.</i>					2	Douglas.	1831.0	62.12		
1	Malaspina.	1790.8	29.48			3	Belcher.	1839.5	61.06		
2	Belcher.	1837.5	31.86			4	Perry.	1843.7	61.98		
3	Haig.	1858.3	32.50			5	Trowbridge.	1854.4	60.99		
4	Harkness.	1866.4	31.93			6	Throckmorton.	1873.7	61.21		
	<i>Acapulco, Mexico.</i>					7	Nichols.	1881.3	61.21		
1	Malaspina.	1791.3	36.12				<i>San Francisco, Cal.</i>				
2	Humboldt.	1803.2	38.88			1	Kotzebue.	1815.8	62.77		
3	Belcher.	1838.5	37.96			2	Douglas.	1831.1	62.97		
4	Harkness.	1866.4	39.90			3	Belcher.	1837.5	61.90		
5	Nichols.	1880.9	40.14			4	Belcher.	1839.5	62.10		
	<i>Mexico, Mexico.</i>					5	Davidson and Roe.	1852.1	62.35		
1	Alzate.	1778.5	38.00			6	Friesach.	1858.4	62.78		
2	Humboldt.	1799.5	42.17			7	Harkness.	1866.5	62.37		
3	Humboldt.	1803.9	42.17			8	Davidson, Throckmorton, and Eimbeck.	1873.9	62.08		
	<i>Sonntag and Mueller.</i>	1857.9	41.43(?)			9	Dall, Baker, and Nichols.	1880.7	62.31		
4	Reyes.	1879.8	44.86			10	Eimbeck, Marr, Nichols, and Lawson.	1881.5	62.38		
5	Barcena.	1884.3	45.01			11	Davidson and Marr.	1884.7	62.34		
	<i>San Blas, Mexico.</i>						<i>Cape Disappointment, Wash. Terr.</i>				
1	Malaspina.	1791.3	43.19				Douglas.	1830.8	69.50		
2	Belcher.	1837.5	45.40			1	Belcher.	1839.5	69.45		
3	Belcher.	1838.5	41.60			2	Eimbeck.	1873.8	69.23		
4	Belcher.	1839.5	44.54			3	Nichols.	1881.8	69.30		
5	Nichols.	1880.9	46.35			4					
	<i>Magdalena Bay, Lower California.</i>						<i>Fort Vancouver, Wash. Terr.</i>				
	Du Petit Thouars.	1837.5	50.72(?)			1	Douglas.	1830.9	69.66		
1	Belcher.	1839.5	46.57			2	Belcher.	1839.5	69.37		
2	Harkness.	1866.4	48.53			3	Haig.	1860.3	69.29		
3	Eimbeck.	1873.2	48.15				<i>Nootka Sound, Vancouver Island.</i>				
4	Nichols.	1881.1	48.31			1	Cook.	1778.3	72.48		
	<i>San Diego, Cal.</i>					2	Malaspina.	1791.6	70.35		
	Vancouver.	1793.9	59.22(?)			3	Vancouver.	1792.8	73.93		
1	Belcher.	1839.5	57.10			4	Nichols.	1881.7	71.55		
2	Emory.	1849.5	57.55				<i>York Factory, British N. A.</i>				
3	Trowbridge.	1853.8	57.64			1	Lefroy.	1843.6	83.79		
4	Harkness.	1866.5	57.90			2	Rae.	1846.1	83.71		
5	Throckmorton.	1872.9	57.95			3	Rae.	1847.7	83.78		
6	Nichols.	1881.3	57.85			4	Blakiston.	1857.6	83.88		
	<i>Los Angeles, Cal.</i>					5	Klotz.	1884.7	83.78		
1	Baker.	1882.8	59.51				<i>Norway House, British N. A.</i>				
2	Baker.	1883.5	59.51				Franklin.	1819.8	83.67(?)		
3	Baker and Terry, jr.	1884.5	59.49			1	Lefroy.	1844.1	81.17		
4	Terry, jr.	1885.3	59.50			2	Klotz.	1884.6	81.21		

TABLE II.—Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.—Continued.

No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.	No.	Locality and observer.	Year and fraction.	Observed dip.	Computed dip.	$\Delta\theta$ O—C.
	<i>Cumberland House, British N. A.</i>		°	°	°		<i>Unalashka, Alaska—Cont'd.</i>		°	°	°
	Franklin.	1819.9	83.20(?)			3	Lütke.	1827.6	68.42		
	Franklin.	1820.4	84.57(?)			4	Lütke.	1829.5	68.43		
1	Franklin.	1825.5	80.35			5	Tebenkoff.	1849.5	68.37		
2	Lefroy.	1844.1	80.42			6	Dall and Baker.	1880.7	67.60		
3	Klotz.	1884.5	80.39				<i>Port Clarence, Grantley Bay, Alaska.</i>				
	<i>Sitka, Alaska.</i>					1	Collinson.	1850.5	75.80		
	La Perouse.	1786.6	73.50(?)			2	Collinson and Maguire.	1854.5	76.50		
1	Golovnin.	1818.5	76.55			3	Wijkander.	1879.5	76.08		
2	Lütke.	1827.5	75.92			4	Dall and Baker.	1880.7	76.07		
3	Erman.	1829.9	75.84				<i>Petropavlovsk, Kamchatka.</i>				
4	Belcher.	1837.5	75.86			1	King.	1779.6	63.08		
5	Belcher.	1839.5	75.82			2	Krusenstern.	1804.7	63.53		
6	Russian Observatory.	1842.5	75.85			3	Beechey and Lütke.	1827.6	64.08		
7	Russian Observatory.	1845.5	75.91			4	Erman.	1829.8	63.82		
8	Collinson.	1851.0	76.33			5	Du Petit Thouars.	1837.7	64.08		
9	Dall and Baker.	1880.4	75.20			6	Officer of frigate Aurora.	1854.5	64.78		
10	Nichols.	1881.7	75.28			7	Onazevich.	1876.6	64.23		
	<i>Unalashka, Alaska.</i>										
1	Cook.	1778.8	69.39								
2	Kotzebue.	1817.5	68.75								

The observations at Halifax, Quebec and Montreal are insufficient for presentation in an analytical form; but the latest observations at these places agree in indicating an apparently uniform decrease of dip between 1860 and 1880, viz:

$$\text{At Halifax, } a_{1860 \text{ to } 1882} = -2.3$$

$$\text{At Quebec, } a_{1860 \text{ to } 1880} = -1.6$$

$$\text{At Montreal, } a_{1858 \text{ to } 1880} = -1.2$$

The value of  $a_{1885}$  is probably slightly greater in each case. There is a faint indication of the *secondary* minimum (about 1838 to 1844), referred to above.

For the stations Cambridge and Boston, New Haven, Albany and Greenbush, New York, Philadelphia, Baltimore, Washington, Toronto, Cleveland, Detroit and Saint Louis, we have a general likeness in the features of the secular variations, *i. e.*, they exhibit the *secondary* minimum, for which we find, on the average, the epoch  $1840.5 \pm 2.0$  years, and they show the subsequent *secondary* maximum, which we find to have occurred, on the average, in  $1860.0 \pm 3.5$  years. If this subordinate wave be persistent, its period would be about  $39 \pm 8$  years. Its range is barely one-quarter of a degree.

After the occurrence of the maximum, and up to the present time, there is noted a regular decrease of dip at all the stations.

The following expressions were obtained for the stations, the second column giving the limit of applicability:

Stations.	Limit.	Results.
Cambridge and Boston, Mass.	1835 to 1885	$\theta = 74.35 + .0120 \Delta t - .000126 \Delta t^2 - .0000350 \Delta t^3$
New Haven, Conn.	1835 to 1885	$\theta = 73.56 + .0108 \Delta t - .000038 \Delta t^2 - .0000274 \Delta t^3$
Albany and Greenbush, N. Y.	1830 to 1885	$\theta = 74.88 + .0170 \Delta t + .000016 \Delta t^2 - .0000350 \Delta t^3$
New York, N. Y.	1820 to 1885	$\theta = 72.75 + .0052 \Delta t + .000243 \Delta t^2 - .0000303 \Delta t^3$
Philadelphia, Pa.	1830 to 1885	$\theta = 72.08 + .0135 \Delta t + .000158 \Delta t^2 - .0000318 \Delta t^3$
Baltimore, Md.	1830 to 1885	$\theta = 71.66 + .0040 \Delta t + .000819 \Delta t^2 - .0000383 \Delta t^3$
Washington, D. C.	1840 to 1885	$\theta = 71.38 - .0025 \Delta t - .000260 \Delta t^2 - .0000100 \Delta t^3$
Toronto, Canada.	1840 to 1885	$\theta = 75.32 + .0079 \Delta t + .000118 \Delta t^2 - .0000208 \Delta t^3$
Cleveland, Ohio.	1840 to 1885	$\theta = 73.21 + .0055 \Delta t + .000366 \Delta t^2 - .0000250 \Delta t^3$
Detroit, Mich.	1840 to 1885	$\theta = 73.63 + .0057 \Delta t + .000161 \Delta t^2 - .0000175 \Delta t^3$
Saint Louis, Mo.	1820 to 1885	$\theta = 69.56 + .0127 \Delta t + .000052 \Delta t^2 - .0000270 \Delta t^3$

We have, accordingly, the annual change  $a_{1885}$  as follows:

Station.	Annual change.	Station.	Annual change.
Cambridge and Boston.	- 7.5	Washington.	- 3.5
New Haven.	- 5.6	Toronto.	- 2.5
Albany and Greenbush.	- 6.6	Cleveland.	- 3.6
New York.	- 5.4	Detroit.	- 2.8
Philadelphia.	- 5.5	Saint Louis.	- 5.0
Baltimore.	- 4.8		

which values, in the absence of any additional information, may be used for a few years to come.

For use in connection with the secular variations of the horizontal component of the force and of the total force, we have formed two groups of stations, exhibiting for every fifth year since 1830 the dip as computed by the preceding formula. These groups are the same as those given further on in the discussion of the secular variation of the horizontal force, and the two averages are graphically exhibited on the accompanying diagram.

Stations.	Jan. 1, 1830.	1835.	1840.	1845.	1850.	1855.	1860.	1865.	1870.	1875.	1880.	Jan. 1, 1885.
Group I.	°	°	°	°	°	°	°	°	°	°	°	°
Cambridge, Mass.	74.340	74.260	74.252	74.291	74.350	74.403	74.422	74.384	74.260	74.025	73.652	73.116
New Haven, Conn.	73.548	73.481	73.475	73.509	73.560	73.611	73.637	73.621	73.542	73.379	73.110	72.719
New York, N. Y.	72.985	72.829	72.752	72.734	72.750	72.778	72.796	72.781	72.709	72.559	72.307	71.932
Sandy Hook, N. J.*	72.865	72.709	72.632	72.614	72.630	72.658	72.676	72.661	72.589	72.439	72.187	71.812
Albany, N. Y.	74.826	74.746	74.747	74.799	74.880	74.961	75.017	75.020	74.946	74.769	74.459	73.995
Average, type I.	73.713	73.605	73.572	73.589	73.634	73.682	73.710	73.693	73.609	73.434	73.143	72.715

\* Same as New York minus  $0^{\circ}.12$ , which is an average observed difference.



*Groups and stations.—Continued.*

Stations.	Jan. 1, 1830.	1835.	1840.	1845.	1850.	1855.	1860.	1865.	1870.	1875.	1880.	Jan. 1, 1885.
Group II.	°	°	°	°	°	°	°	°	°	°	°	°
Philadelphia, Pa.	72. 127	72. 021	71. 993	72. 020	72. 080	72. 148	72. 199	72. 210	72. 159	72. 020	71. 768	71. 381
Baltimore, Md.	72. 214	71. 913	71. 740	71. 665	71. 660	71. 695	71. 744	71. 775	71. 762	71. 674	71. 483	71. 163
Washington, D. C.	71. 406	71. 393	71. 389	71. 387	71. 380	71. 361	71. 319	71. 251	71. 146	71. 000	70. 801	70. 547
Toronto, Canada. *	75. 48	75. 35	75. 285	75. 252	75. 322	75. 387	75. 413	75. 350	75. 275	75. 20	75. 03	74. 88
Cleveland, Ohio.	73. 446	73. 293	73. 217	73. 194	73. 210	73. 244	73. 277	73. 291	73. 266	73. 185	73. 029	72. 781
Detroit, Mich.	73. 720	73. 640	73. 607	73. 608	73. 630	73. 660	73. 685	73. 692	73. 668	73. 600	73. 474	73. 277
Average, type II.	73. 066	72. 935	72. 872	72. 854	72. 880	72. 916	72. 939	72. 928	72. 880	72. 780	72. 598	72. 338

\* Values for 1830 and 1835 are interpolated.

Group III, composed of stations on the western coast, could not be established in consequence of the imperfections of the data, though it will be seen further on that the observations of the horizontal force admitted of such tabulation.

Turning to the Southern States and the West India Islands and Mexico, we find at Fernandina and Key West, Fla., the dip apparently to have been slowly decreasing since about 1860. In Louisiana it would seem that the dip has recently been stationary, the latest observations at New Orleans and Southwest Pass apparently pointing to a slight increase at present, whereas in Texas, at Dollar Point, near Galveston, observations show a decided increase of dip. Thus in passing from the eastern to the western gulf coast the present slight decrease in Florida vanishes and reverses in Louisiana, and becomes an increase in Texas. In other words, the subordinate extreme in these latitudes has just been passed in the east but has not yet been reached in the west.

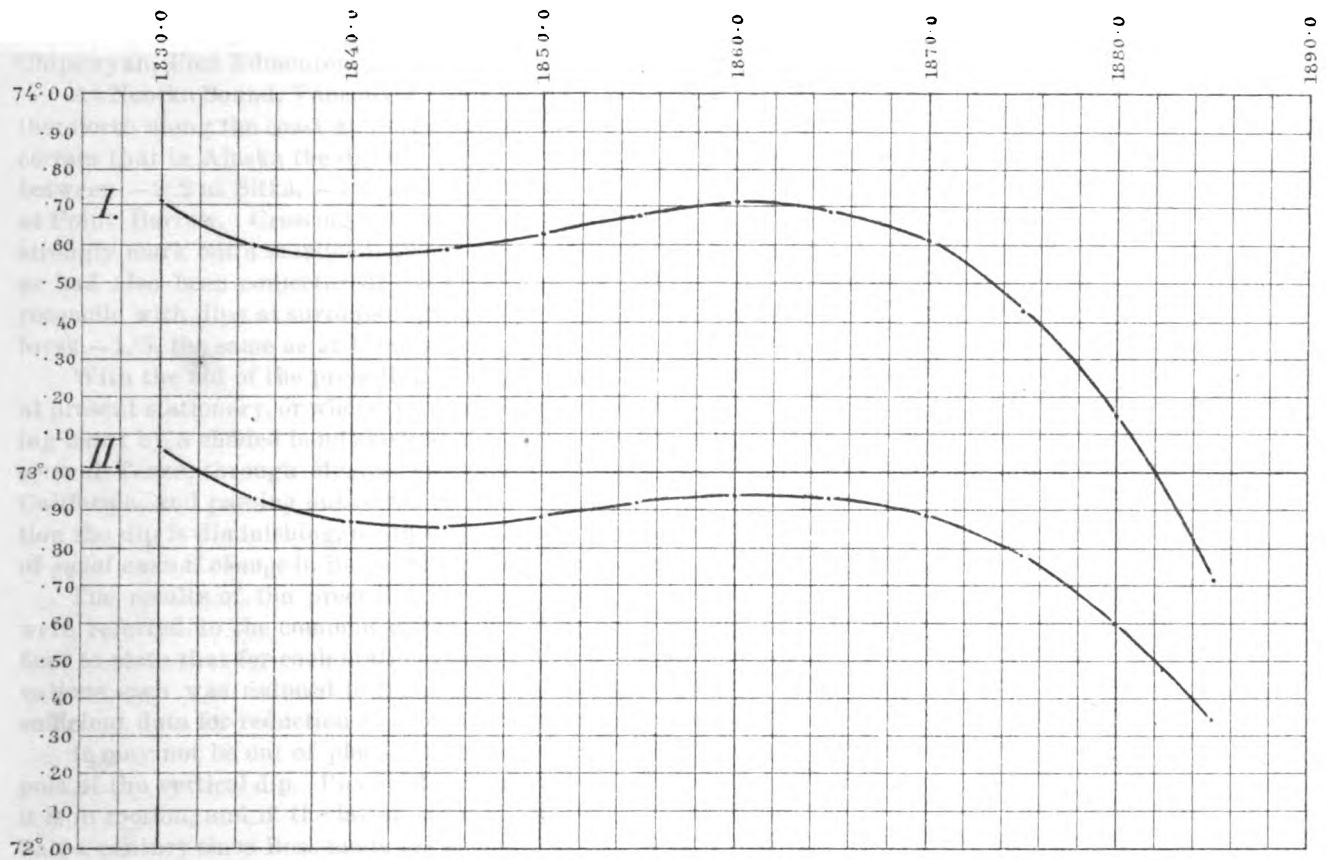
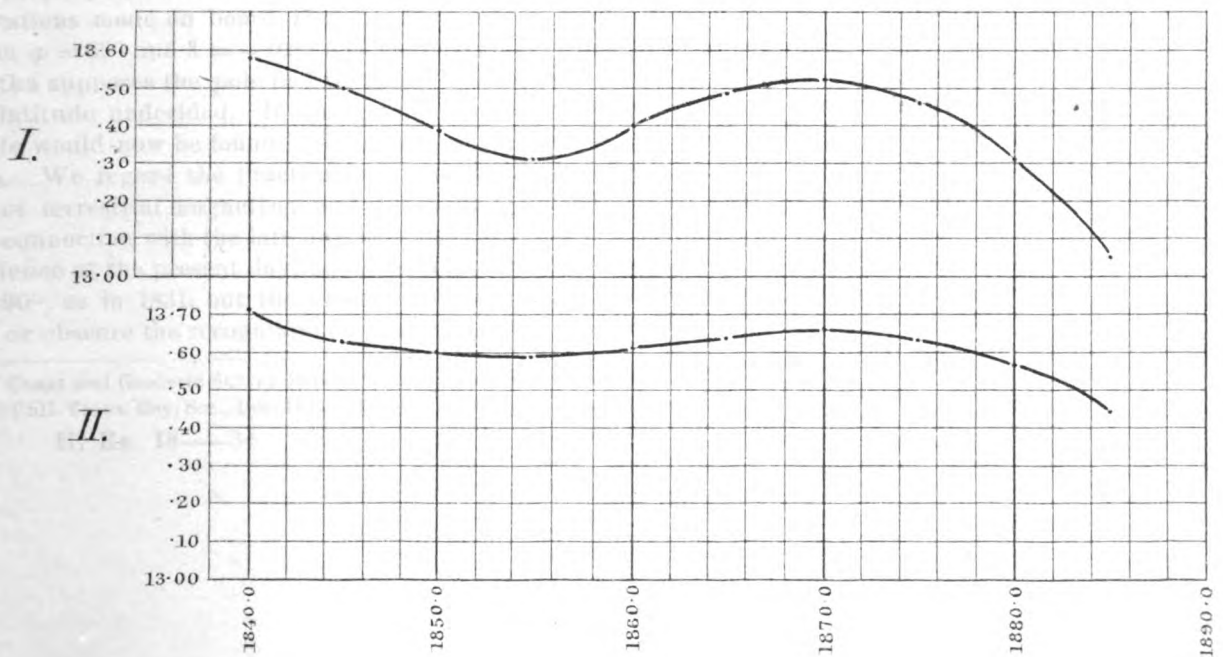
In the West Indies and Mexico it is difficult to recognize what has been going on in the dip in consequence of the contradictory testimony of the observations, but forming a general idea of the change from comparison of all the stations it would appear that in the region bounded by Nassau, Havana, and Saint Thomas the dip is at present nearly stationary or persisting about an extreme phase. In Mexico and Central America, or in the region including Panama, Acapulco, Mexico, and San Blas, the data are more definite and the dip appears to have been *increasing* throughout this century, but the maximum has probably not yet been reached.

In connection with the above it may be stated that at Rio de Janeiro, Brazil, the change in the dip is no less remarkable than the change in the declination; we are here presented with a steady *increase* of north dip between La Caille's observation in 1751\* (dip =  $-20^{\circ} 0'$ ) and Harkness's observation in 1866 (dip =  $-11^{\circ} 47'$ ), and the same phenomenon is noted at Valparaiso, Chili, between the observations of Malaspina\* in 1793 (dip =  $-44^{\circ} 58'$ ), and Harkness's observation of 1866 (dip =  $-35^{\circ} 23'$ ). No such large changes have been observed within the area of the United States. At Havana the present annual change is probably less than  $+0.8$ , at Acapulco about  $+1.0$ , at Mexico and San Blas it may be  $+1.5$  to  $+2.0$ , but at Magdalena Bay, Lower California, Mexico, the annual change seems to have become zero at present.

Passing north to the coast of California, Oregon, and Washington Territory we meet with several cases of embarrassing discordant observations; nevertheless we can clearly discern that at San Diego, Los Angeles, Santa Barbara, and Monterey the dip at present undergoes either no or but a very slight annual change. The state of the dip at San Francisco, at Cape Disappointment (mouth of the Columbia River), and at Fort Vancouver is probably just past the extreme and is very slowly decreasing, though we are unable to assign the amount.

Over the vast regions in British North America north of the boundary of Dakota and extending to the shores of Hudson's Bay, and embracing Lake Winnipeg, observations at York Factory

\* Astronomische Nachrichten, No. 954, 1855.

*Type-Curves of the secular Variation of the Dip.**Type-Curves of the secular Variation of the total Intensity.*



and at the Norway and Cumberland houses make it appear that the dip is now not very different from what it was forty years ago, and probably it has undergone but little change during the interval; in this region the present annual change is supposed very small. Further west, at Fort Chipewyan, Fort Edmonton, and Fort Lesser Slave Lake the annual change may be about  $-0'.5$

At Nootka Sound, Vancouver Island, the dip is on the decrease, about  $-0'.7$  for the island; further north along the coast at Port Simpson the annual change seems to be about  $-1'.5$ . It seems certain that in Alaska the dip has been *decreasing* since (about) 1852, with an annual rate varying between  $-2'.2$  at Sitka,  $-1'.5$  at Unalashka,  $-1'.0$  at Port Clarence, near Bering Strait, and  $-1'.2$  at Point Barrow. Crossing the strait to Asia the observed dips at Petropavlovsk, Kamchatka, strongly mark out a maximum about 1854, which appears supported by the dips at Port Clarence, as had also been conjectured\* for Point Barrow. The Unalashka dips appear to be difficult to reconcile with dips at surrounding stations. Supposed present annual change of dip at Petropavlovsk  $-1'.5$ , the same as at Unalashka.

With the aid of the preceding results we can roughly trace out the region over which the dip is at present stationary, or where the annual change is zero. This region is marked on the accompanying chart by a shaded band skirting the northern coast of Cuba, passing over lower Louisiana and central Texas, through Mexico, crossing the Gulf of California, following the coast of Southern California, and passing out to sea off San Francisco. Everywhere north of this belt of demarcation the dip is diminishing, south of it increasing in consequence of secular variation, and curves of *equal annual change* in its vicinity would run nearly parallel to it.

The results of the preceding investigation supplied the means by which the observed dips were referred to the common epoch 1855.0, as given in Table I, and, in connection with it, it suffices to state that for each station the latest observation was used, or in case of several late observations each was reduced to the epoch and the mean inserted in the table. A blank indicates insufficient data for reduction and the use of a single decimal that the dip is only roughly known.

It may not be out of place here to offer a few remarks respecting the present position of the pole of the vertical dip. Physicists are not agreed whether this pole is fixed in position or whether it is in motion, and if the latter, what is the direction and velocity of the change. It is now over half a century since Ross made his memorable and successful approach to this point and found it † (June, 1831) in  $\varphi = 70^\circ 05'.3$ ,  $\lambda = -96^\circ 45'.8$ , and no serious attempt has since been made either to verify it or to demonstrate by actual observation any change in its position. It seems perhaps more reasonable to suppose its range of displacement to be quite limited than to assign to it, as has been done, a path surrounding the geographical pole, and to be described in several centuries. Observations made on board Her Majesty's ship Brazen in 1813 pointed to approaching verticality in  $\varphi = 69^\circ$  and  $\lambda = -92^\circ$ ; and more recently, from the behavior of his compass, Lieutenant Schwatka supposes the pole in 1879 to have shifted to  $\lambda = -99^\circ 35'$ , while he leaves any change in its latitude undecided. If the secular diminution of the dip extends to this northern region the pole would now be found in a higher latitude than that given by Ross, but of this we are not certain. We regard the practical solution of this problem as one of great importance for the theory of terrestrial magnetism, and it is to be regretted that no steps were taken toward its solution in connection with the late international circumpolar explorations.

Science at the present day, however, would not be satisfied with a single line of approach to a dip of  $90^\circ$ , as in 1831, but the whole region would need exploration since local deflections may vitiate or obscure the recognition of the true place of verticality.

\* Coast and Geodetic Survey Report for 1883, App. No. 13, p. 339.

† Phil. Trans. Roy. Soc., Dec. 1833. According to Gauss' theory the pole is in  $\varphi = 73^\circ 35'$   $\lambda = -95^\circ 39'$ .

## PART III.

## SECULAR VARIATION OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE AND OF THE TOTAL INTENSITY IN THE UNITED STATES.

It was not until 1833 that Gauss showed\* how the earth's magnetic intensity could be expressed in absolute measure; and in 1836 Weber† constructed the portable magnetometer. Before this time no satisfactory investigation or inquiry could be made respecting either supposed changes or permanency of the magnetic intensity. Although relative intensity measures had been made as early as 1785, no definite results could be arrived at respecting changes in the intensity of the force in consequence of the unknown, gradual and irregular loss of magnetism of the needles employed in these comparisons. The range of time over which our knowledge of the intensity thus practically extends is barely half a century, though some rough guesses may be made as to earlier results.

A first investigation of the secular variations of the horizontal component and of the total force was attempted by me in Appendix No. 22, Coast Survey Report for 1861. In consequence of the scanty material then at command and the large relative size of observing errors as compared with the effect of the secular change, no very decided results were reached. It appeared, however, that in the eastern parts of the United States, during the twenty years then passed, the horizontal component of the force had been *decreasing* at an annual rate of about 0.001 parts of the force, and that in the western part of the country the horizontal force had been *increasing* at an annual rate a trifle greater than that just given. The direct evidence as to a change in total intensity was inconclusive; however, it was certainly very small, whatever its character may have been.

It was soon noticed that in the east the secular diminution in the horizontal component had come to an end about 1855 or 1860 (at Washington and at Toronto), and that after this a steady increase of this component set in which has continued to the present time.

Respecting the secular variation of the total force, we know from the earliest records at Washington and at Toronto that the intensity was subject to a slow decrease. In the preface to his "Diary of a Magnetic Survey of Canada," Sir J. H. Lefroy remarks (in 1883), "The general evidence is conclusive that in middle latitudes on the American continent the intensity of the earth's magnetic force is now decreasing and has been decreasing for about thirty-five years," a conclusion which was supported by recently (1882) published results of the Coast and Geodetic Survey. In the same volume General Lefroy takes occasion to point out a needed correction to the isodynamic lines in Northwest America as laid down from observations by Sir Edward Sabine in Phil. Trans. Roy. Soc., vol. for 1872, and draws attention to the remarkable development of magnetic (total) force on the eastern side of Lake Winnipeg. A resurvey of this region and a first survey of the vast area to the east of it, between the northern shore of Lake Superior and Georgian Bay and the southern and western shores of Hudson's Bay is absolutely indispensable if we desire an adequate knowledge of the region of great intensity and of the locus and amount of its maximum value.

The leading stations selected for the investigation of the secular variation of the horizontal intensity are the same as those given in connection with the discussion of the changes of the dip.

\* *Intensitas vis magneticæ terrestris ad mensuram absolutam revocata*; auctore C. F. Gauss; Gottingæ, 1833.

† Description of a small portable magnetometer for measuring the absolute intensity of terrestrial magnetism, by Professor Weber. Results of the observations made by the magnetic association in the year 1836, Göttingen. See Taylor's Scientific Memoirs, Vol. II, London, 1841.

TABLE III.—Annual values of observed magnetic horizontal force at prominent stations.

No.	Locality and observer.	Year and fraction.	Observed horizontal force.	No.	Locality and observer.	Year and fraction.	Observed horizontal force.
<i>Halifax, N. S.</i>				<i>West Point and Coldspring, N. Y.—Cont'd.</i>			
1*	Home.	1834.4	3.229	3	Bache.	1843.5	4.033
2*	Home.	1837.4	3.356	4	Schott.	1855.7	3.790
3*	Keely.	1847.5	3.247	<i>New York, N. Y.</i>			
4	Maclear and Bromley.	1873.4	3.385		Sabine.	1822.9	3.981(?)
5	Baylor.	1879.7	3.452	1	Bache and Courtenay.	1835.0	3.973
6	Very.	1881.8	3.459	2	Loomis.	1839.7	4.012
<i>Quebec, Canada.</i>				3	Locke and Bache.	1841.6	4.018
1*	Lefroy.	1842.7	3.023	4	Lefroy and Locke.	1842.6	4.019
2*	Younghusband.	1845.5	3.048	5	Locke, Renwick, and Lefroy.	1844.5	4.023
3	Schott.	1859.5	2.991	6	Locke.	1846.3	4.009
4	Baylor.	1879.7	3.104	7	Schott.	1855.6	3.928
<i>Montreal, Canada.</i>				8	Scott and Goodfellow.	1872.8	3.982
1	Lefroy.	1842.7	3.064	<i>Sandy Hook, N. Y.</i>			
2*	Lefroy and Bache,	1843.3 } 7 }	3.063 3.109	1	Renwick.	1844.6	4.077
3	Younghusband.	1845.5	3.012	2	Schott.	1855.6	3.917
4	Schott.	1859.5	3.111	3	Hilgard (T. C.).	1873.8	4.040
5	Baylor.	1879.7	3.191	4	Baylor.	1879.5	4.078
<i>Cambridge and Boston, Mass.</i>				<i>Philadelphia, Pa.</i>			
1	Loomis.	1839.7	3.658	1	Bache and Courtenay.	1835.5	4.195
2*	Locke and Lefroy.	1842.5	3.650	2	Bache.	1836.7	4.159
3	Locke.	1845.4	3.618	3	Loomis.	1839.7	4.149
4	Lee (T. J.) and Fauntleroy.	1846.7	3.587	4	Bache and Locke.	1841.6	4.175
5	Schott.	1856.6	3.544	5	Bache, Locke, and Lefroy.	1842.5	4.175
6	Friesach.	1856.5	3.542	6	Bache.	1843.6	4.172
7	Smith (W. P.).	1859.2	3.596	7	Bache and Locke.	1844.3	4.164
8	Scott and Goodfellow.	1872.8	3.675	8	Bache.	1845.3	4.167
9	Baylor.	1879.6	3.704	9	Locke.	1846.4	4.143
<i>Providence, R. I.</i>				10	Schott.	1855.7	4.211(?)
1	Bache and Courtenay.	1835.5	3.770	11	Schott.	1862.6	4.124
2	Loomis.	1839.7	3.726	12	Harkness.	1865.8	4.148
3	Lefroy.	1842.7	3.715	13	Scott and Goodfellow.	1872.8	4.161
4	Schott.	1855.6	3.590	14	Baylor.	1877.8	4.211
5	Sherman.	1884.5	3.769		Smith (E.).	1884.7	4.232
6	Baylor.	1885.3	3.814	<i>Baltimore, Md.</i>			
<i>New Haven, Conn.</i>				1	Nicolet.	1832.5	4.228
1	Loomis.	1839.7	3.832	2	Bache.	1840.6	4.265
2	Locke and Lefroy.	1842.5	3.825	3	Locke.	1841.3	4.255
3	Renwick.	1844.7	3.818	4	Lefroy.	1842.8	4.234
	Fauntleroy.	1847.8	3.667(?)	5	Schott.	1856.7	4.203
4	Ruth.	1848.6	3.772	6	Baylor.	1877.8	4.146
5	Schott.	1855.6	3.690	<i>Washington and District of Columbia.</i>			
6	Thorpe.	1878.5	3.861	1	Lefroy.	1842.8	4.8316
7	Sherman.	1884.5	3.870	2	Bache.	1843.0	4.320
8	Sherman.	1885.5	3.860	3	Locke.	1844.3	4.289
<i>Albany and Greenbush, N. Y.</i>				4	Lee (T. J.).	1845.3	4.236
1	Bache and Courtenay.	1835.5	3.578	5	Dean and Bache.	1851.5	4.233
2	Lefroy.	1842.8	3.581	6	Hilgard (J. E.).	1852.4	4.267
3	Locke.	1844.4	3.580	7	Schott.	1855.7	4.250
4	Schott.	1855.6	3.587	8	Schott.	1856.7	4.308
5	Friesach.	1856.7	3.575	9	Schott.	1858.5	4.255
6	Dean.	1858.4	3.586	10	Schott.	1859.5	4.307
6	Baylor.	1879.8	3.645	11	Schott.	1860.7	4.319
<i>West Point and Coldspring, N. Y.</i>				12	Schott.	1862.6	4.284
1	Bache and Courtenay.	1835.5	3.866	13	Schott.	1863.5	4.294
2	Lefroy and Bartlett.	1842.8	3.886	14	Harkness.	1866.8	4.300
				15	Schott and Goodfellow.	1867.5	4.321
				16	Schott.	1868.5	4.334

TABLE III.—Annual values of observed magnetic horizontal force at prominent stations.—Continued.

No.	Locality and observer.	Year and fraction.	Observed horizontal force.	No.	Locality and observer.	Year and fraction.	Observed horizontal force.
<i>Washington and District of Columbia.—Cont'd.</i>				<i>Detroit, Mich.</i>			
17	Schott.	1869.3	4.347	1	Younghusband.	1842.8	3.930
18	Schott.	1870.5	4.352	2	Locke.	1843.4	3.892
19	Schott.	1871.5	4.356	3	Lefroy.	1845.5	3.863
20	Schott.	1872.5	4.360	4	Smith (W. P.).	1859.3	3.838
21	Schott.	1873.5	4.344	5	Smith (W. P.).	1860.4	3.865
22	Schott.	1874.5	4.349	6	Lee (A. N.).	1872.4	3.881
23	Schott.	1875.5	4.353	7	Lee (A. N.).	1873.4	3.880
24	Schott and Hilgard (F. E.).	1876.3	4.356	8	Balley.	1876.4	3.898
25	Schott and Braid.	1877.7	4.369	<i>Cincinnati, Ohio.</i>			
26	Schott, Thorpe, and Baylor.	1878.7	4.368	1	Locke.	1844.4	4.548
27	Elmbeck and Schott.	1879.5	4.370	2	Locke.	1845.3	4.548
28	Baylor.	1880.5	4.375	3	Lefroy.	1849.4	4.527
29	Baylor.	1881.3	4.380	4	Baylor.	1880.9	4.488
30	Elmbeck.	1882.5	4.364	<i>Madison, Wis.</i>			
31	Schott.	1883.5	4.373	1	Locke.	1839.8	3.878
32	Maxfield, Elmbeck, and Schott.	1884.3	4.385	2	Hilgard (F. E.).	1876.8	3.891
33	Schott.	1885.5	4.397	3	Braid.	1877.7	3.913
<i>Pittsburgh and Allegheny, Pa.</i>				4	Suess and Baylor.	1878.8	3.896
1	Bache.	1840.6	4.049	5	Mason.	1879.7	3.908
2	Locke.	1841.2	4.059	6	Mason.	1880.7	3.903
3	Locke.	1842.3	4.056	7	Suess.	1881.9	3.898
4	Locke.	1845.3	4.034	<i>Saint Louis, Mo.</i>			
5	Thorpe.	1878.7	4.129	1	Nicollet.	1836.0	4.814
<i>Toronto, Canada.</i>				2	Locke.	1839.7	4.748
1	Lefroy.	1842.8	3.535	3	Friesach.	1856.8	4.925 (?)
2	Bache.	1843.6	3.537	3	Hilgard (T. C.).	1872.5	4.699
3	Locke.	1844.5	3.540	4	Nipher.	1878.6	4.586 (?)
4	Lefroy.	1845.3	3.548	4	Nipher.	1879.7	4.673
5	Lefroy.	1846.5	3.542	<i>Nassau, New Providence Island.</i>			
6	Lefroy.	1847.5	3.538	1	Ackley.	1879.1	6.503
7	Lefroy.	1848.5	3.534	<i>Havana, Cuba.</i>			
8	Lefroy.	1849.5	3.537	1	Humboldt.	1801.0	6.100 (?)
9	Lefroy.	1850.5	3.532	2	Sabine.	1822.5	6.970
10	Lefroy.	1851.5	3.530	3	Friesach.	1857.1	6.921
11	Lefroy.	1852.5	3.515	4	Ackley.	1879.2	6.847
12	Kingston.	1855.8	3.515	<i>Saint Thomas, West Indies.</i>			
13	Kingston.	1856.5	3.505	1	Friesach.	1857.1	6.723
14	Kingston.	1857.5	3.488	2	Harkness.	1865.9	6.758
15	Kingston.	1858.5	3.490	<i>Panama, United States of Colombia.</i>			
16	Kingston.	1859.5	3.481	1	Belcher.	1837.5	7.743
17	Kingston.	1860.5	3.479	2	Haig.	1858.3	7.654
18	Kingston.	1861.5	3.484	3	Harkness.	1866.4	7.614
19	Kingston.	1862.5	3.485	<i>Acapulco, Mexico.</i>			
20	Kingston.	1863.5	3.489	1	Belcher.	1838.5	7.910
21	Kingston.	1864.5	3.493	2	Harkness.	1866.4	7.740
22	Kingston.	1865.5	3.493	3	Nichols.	1880.9	7.518
23	Kingston.	1866.5	3.493	<i>Mexico, Mexico.</i>			
24	Kingston.	1867.5	3.498	1	Humboldt.	1803.9	6.690 (?)
25	Kingston.	1868.5	3.498	2	Sonntag and Mueller.	1857.9	7.576
26	Kingston.	1869.5	3.499	3	Keyes.	1879.8	7.480
27	Kingston.	1870.5	3.498	<i>San Blas, Mexico.</i>			
28	Kingston.	1871.5	3.500	1	Belcher.	1838.5	7.590
29	Carpmael.	1885.3	3.591	2	Belcher.	1839.5	7.421
<i>Cleveland, Ohio.</i>				3	Nichols.	1880.9	7.204
1	Younghusband.	1842.8	3.981				
2	Locke.	1843.6	4.005				
3	Smith (W. P.).	1859.5	3.956				
4	Goodfellow.	1871.8	4.000				
5	Lee (A. N.).	1872.5	4.017				
6	Lee (A. N.).	1873.5	3.996				
7	Baylor.	1880.5	3.996				

TABLE III.—Annual values of observed magnetic horizontal force at prominent stations.—Continued.

No.	Locality and observer.	Year and fraction.	Observed horizontal force.	No.	Locality and observer.	Year and fraction.	Observed horizontal force.
<i>Magdalena Bay, Lower California.</i>				<i>Fort Vancouver, Wash.</i>			
1	Belcher.	1839.5	7.160	1	Douglas.	1830.9	4.442
2	Harkness.	1866.4	7.176	2	Belcher.	1839.5	4.475
3	Eimbeck.	1873.2	6.926	3	Haig.	1860.3	4.618
4	Nichols.	1881.1	7.032	4	Lawson.	1881.8	4.547
<i>San Diego, Cal.</i>				<i>Nootka Sound, Vancouver Island.</i>			
1	Belcher.	1839.5	6.142	1	Nichols.	1881.7	4.083
2	Trowbridge.	1853.8	6.271	<i>York Factory, British N. A.</i>			
3	Harkness.	1866.5	6.261	1	Lefroy.	1843.6	1.505
4	Throckmorton.	1872.9	6.159	2	Klotz.	1884.7	1.508
5	Nichols.	1881.3	6.104	<i>Norway House, British N. A.</i>			
<i>Los Angeles, Cal.</i>				1	Lefroy.	1844.1	2.175
1	Baker.	1882.8	5.913	2	Klotz.	1884.6	2.148
2	Baker.	1883.5	5.919	<i>Cumberland House, British N. A.</i>			
3	Baker and Terry.	1884.5	5.915	1	Lefroy.	1844.1	2.357
4	Terry.	1885.3	5.911	2	Klotz.	1884.5	2.345
<i>Santa Barbara, Cal.</i>				<i>Sitka, Alaska.</i>			
1	Douglas.	1831.4	5.861	1	Lütke.	1827.5	3.197
2	Belcher.	1839.5	5.925	2	Erman.	1829.9	3.197
3	Davidson and Throckmorton.	1869.9	5.967	3	Belcher.	1839.5	3.207
4	Nichols.	1881.3	5.871	4	Dall and Baker.	1880.4	3.310
<i>Monterey, Cal.</i>				5	Nichols.	1881.7	3.293
1	Douglas.	1831.0	5.629	<i>Unalashka, Alaska.</i>			
2	Belcher.	1839.5	5.666	1	Lütke.	1827.6	4.468
3	Trowbridge.	1854.4	5.802	2	Lütke.	1829.5	4.584
4	Throckmorton.	1873.7	5.696	3	Dall and Baker.	1880.7	4.456
5	Nichols.	1881.3	5.663	4	Marr.	1883.7	4.386
<i>San Francisco, Cal.</i>				<i>Port Clarence and Grantley Bay, Alaska.</i>			
1	Douglas.	1831.1	5.495	1	Wijkander.	1879.5	3.028
2	Belcher.	1839.5	5.524	2	Dall and Baker.	1880.7	3.022
3	Friesach.	1858.4	5.576	<i>Petropavlovsk, Kamchatka.</i>			
4	Harkness.	1866.5	5.643	1	Erman.	1829.8	4.964
5	Davidson, Throckmorton, and Eimbeck.	1873.9	5.543	2	Du Petit Thouars.	1837.7	4.856
6	Dall, Baker, and Nichols.	1880.7	5.514				
7	Eimbeck, Marr, Nichols, and Lawson.	1881.5	5.523				
8	Marr.	1883.4	5.481				
9	Davidson and Marr.	1884.7	5.507				
<i>Cape Disappointment, Wash.</i>							
1	Douglas.	1830.8	4.436				
2	Belcher.	1839.5	4.394				
3	Eimbeck.	1873.8	4.537				
4	Nichols.	1881.8	4.482				

To ascertain in general the characteristic features of the change in the horizontal component, the observed values of  $H$  were plotted for each station. It then became apparent that, perhaps with the exception of a few stations, the observed data were insufficient to trace out the law with distinctness at any one station, but that *collectively* fairly satisfactory results could be had. Three distinct types of change could be recognized, and the stations exhibiting like types were grouped and their results united into a mean, as shown in the following table. The values of  $H$ , as tabulated for every fifth year, are the result of a free-hand curve drawn among the dots representing the observed values, in order that their accidental errors may be eliminated as far as possible.

The observations at the three Canadian stations, Halifax, Quebec and Montreal, were found too irregular to be combined; they concur, however, in indicating *increasing* force since 1860 or some earlier date. The stations in the West Indies, Central America, and Mexico likewise could not be treated in the manner proposed, from insufficiency of observations, but they clearly indicate



*decreasing* force from a date anterior to that just mentioned. This matter will be referred to again in connection with the annual change. In Alaska, likewise, the horizontal component is apparently at present decreasing.

*Type-curve No. I, showing secular variation of the horizontal intensity (H) for the northeastern part of the United States (see diagram).*

Stations.	(Jan. 1), 1830.	1835.	1840.	1845.	1850.	1855.	1860.	1865.	1870.	1875.	1880.	(Jan. 1), 1885.
Cambridge.	----	----	3.66	3.61	3.565	3.555	3.59	3.62	3.66	3.685	3.70	3.715
New Haven.	----	----	3.83	3.805	3.75	3.70	3.72	3.76	3.80	3.835	3.86	3.87
New York.	----	----	4.02	4.01	3.97	3.93	3.94	3.955	3.97	3.99	4.01	4.03
Sandy Hook.	----	----	4.09	4.06	3.99	3.925	3.94	3.98	4.01	4.04	4.07	4.10
Albany.	----	----	3.60	3.58	3.58	3.58	3.585	3.60	3.615	3.63	3.645	3.66
Average.	----	----	3.840	3.813	3.771	3.738	3.755	3.783	3.811	3.836	3.857	3.875

*Type-curve No. II, showing secular variation of the horizontal intensity (H) for the eastern part of the United States (see diagram).*

Stations.	(Jan. 1), 1830.	1835.	1840.	1845.	1850.	1855.	1860.	1865.	1870.	1875.	1880.	(Jan. 1), 1885.
Philadelphia.	----	----	4.18	4.15	4.14	4.13	4.13	4.14	4.16	4.19	4.22	4.23
Baltimore.	----	----	4.25	4.23	4.21	4.20	4.21	4.21	4.22	4.24	4.25	4.27
Washington.	----	----	4.285	4.265	4.250	4.265	4.290	4.315	4.335	4.355	4.370	4.395
Toronto.	----	----	3.565	3.545	3.535	3.510	3.480	3.495	3.500	3.52	3.56	3.589
Cleveland.	----	----	4.00	3.985	3.975	3.965	3.965	3.975	3.985	3.995	4.01	4.03
Detroit.	----	----	3.91	3.895	3.865	3.850	3.855	3.86	3.87	3.89	3.905	3.92
Average.	----	----	4.032	4.012	3.996	3.987	3.988	3.998	4.012	4.032	4.053	4.072

*Type-curve No. III, showing secular variation of the horizontal intensity (H) for the western coast of the United States (see diagram).*

Stations.	(Jan. 1), 1830.	1835.	1840.	1845.	1850.	1855.	1860.	1865.	1870.	1875.	1880.	(Jan. 1), 1885.
San Diego.	6.12	6.14	6.16	6.195	6.22	6.25	6.265	6.245	6.20	6.15	6.105	6.07
Santa Barbara.	5.87	5.89	5.92	5.935	5.945	5.955	5.96	5.95	5.94	5.92	5.885	5.84
Monterey.	5.63	5.645	5.675	5.71	5.75	5.77	5.76	5.75	5.72	5.69	5.665	5.65
San Francisco.	5.495	5.51	5.52	5.54	5.56	5.575	5.59	5.59	5.58	5.545	5.515	5.49
Fort Vancouver.	4.44	4.46	4.48	4.515	4.55	4.565	4.585	4.585	4.575	4.56	4.54	4.53
Average.	5.511	5.529	5.551	5.579	5.605	5.623	5.632	5.624	5.603	5.573	5.542	5.516

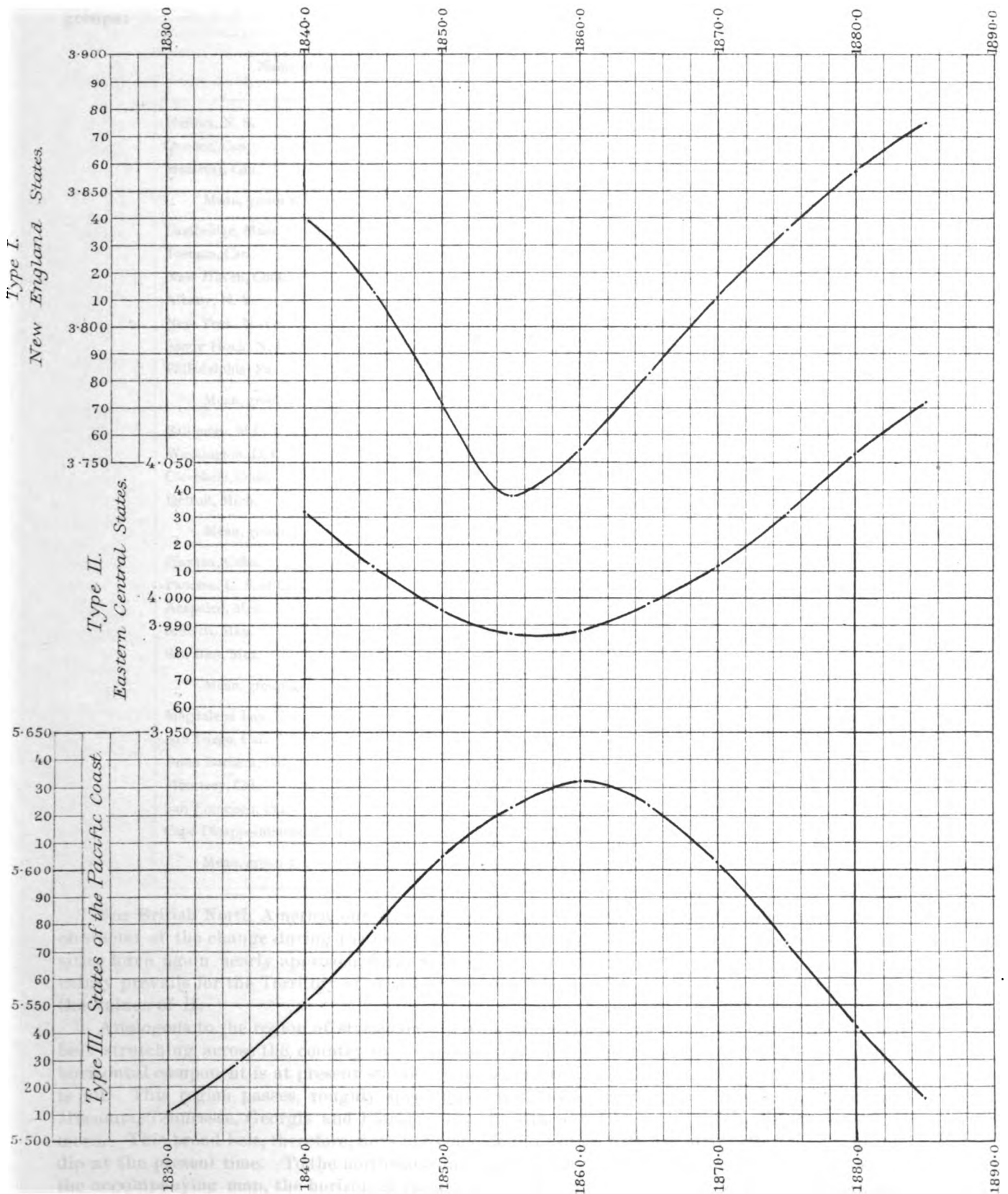
The annual change  $a = \frac{dH}{dt}$  can be made out for a number of stations, and is found to have been sufficiently uniform for some years past to be deduced directly from recent observations; the average annual rate of change thus made out results from observations made subsequent to the time of the last maximum or minimum.

Let  $a$  = recent annual change of the horizontal force, expressed in absolute measure (English units), + when the force is increasing, - when decreasing,

and  $a_r$  = recent annual change of the horizontal force when expressed in parts of  $H$ ; hence  $a_r = \frac{a}{H_m}$

where  $H_m$  = mean value of  $H$  during the interval  $t_1 - t_2$ .

*Type-Curves of the secular Variation of the horizontal Intensity;*





We have the following values of  $a$  and  $a_1$ , together with their mean values for certain geographical groups:

Name of station.	Between epochs $t_1$ and $t_{11}$ .	Annual change $a$ .	Annual change $a_1$ .
Halifax, N. S.	1848(?) 1882	+ .0062	+ .0019
Quebec, Can.	1860 1880	+ .0056	+ .0018
Montreal, Can.	1860 1880	+ .0040	+ .0013
Mean, group 1.	1856 1881	+ .0053	+ .0017
Cambridge, Mass.	1856 1880	+ .0068	+ .0019
Toronto, Can.	1871 1885	+ .0065	+ .0018
New Haven, Conn.	1855 1885	+ .0058	+ .0015
Albany, N. Y.	1857 1880	+ .0030	+ .0009
New York, N. Y.	1856 1873	+ .0032	+ .0008
Sandy Hook, N. J.	1856 1880	+ .0067	+ .0017
Philadelphia, Pa.	1863 1885	+ .0049	+ .0012
Mean, group 2.	1859 1881	+ .0053	+ .0014
Baltimore, Md.	1857 1878	+ .0020	+ .0005
Washington, D. C.	1856 1885	+ .0041	+ .0009
Cleveland, Ohio.	1860 1881	+ .0020	+ .0005
Detroit, Mich.	1860 1876	+ .0029	+ .0007
Mean, group 3.	1858 1880	+ .0028	+ .0007
Havana, Cuba.	1857 1879	— .0034	— .0005
Panama, U. S. of Col.	1858 1866	— .0050	— .0007
Acapulco, Mex.	1866 1881	— .0089	— .0012
Mexico, Mex.	1858 1880	— .0044	— .0006
San Blas, Mex.	1840(?) 1881	— .0053	— .0007
Mean, group 4.	1856 1877	— .0054	— .0007
Magdalena Bay, L. C.	1866 1881	— .0096	— .0014
San Diego, Cal.	1866 1881	— .0105	— .0017
Santa Barbara, Cal.	1870 1881	— .0084	— .0014
Monterey, Cal.	1874 1881	— .0043	— .0008
San Francisco, Cal.	1874 1884	— .0048	— .0006
Cape Disappointment, W. T.	1874 1882	— .0069	— .0015
Mean, group 5.	1874 1882	— .0070	— .0012

For British North America our data are insufficient to give any definite information of the character of the change during the last forty years, and apparently the present horizontal intensities have again nearly approached the values they had at the earlier epoch. The same uncertainty prevails for the Territory of Alaska respecting the past as well as the present changes in the values of  $H$ .

Analogous to the region of stationary dip we also recognize, but much less distinctly, a broad belt stretching across the country in a northwesterly and southeasterly direction, in which the horizontal component is at present stationary, or where the annual change of the horizontal force is nil. This region passes, roughly speaking, through western Montana, Wyoming, Nebraska, Missouri, Tennessee, Georgia and Florida, possibly with a width of two hundred statute miles or more. This broad belt, therefore, does not coincide in position with a similar belt of unchangeable dip at the present time. To the northward and eastward of this belt of demarkation, as shown on the accompanying map, the horizontal component is in a state of increase, to the southward and westward of it in a state of decrease. In either case the annual change, as also in the case of the

annual change of the dip, becomes greater the farther a place is distant from the respective marked regions of constancy.

#### SECULAR VARIATION OF THE TOTAL INTENSITY OF THE MAGNETIC FORCE.

The data for the investigation of the variation in the total intensity are those already given for the dip and horizontal force, and they need only combination to yield the results desired.

The following table contains the values of the intensity  $F$ , as computed from the corresponding values of  $H$  and  $\theta$  for types I and II, the data for other types being either incomplete or wanting.  $F$  is expressed in British units.

Stations.	(Jan. 1), 1830.	1835.	1840.	1845.	1850.	1855.	1860.	1865.	1870.	1875.	1880.	(Jan. 1), 1885.
Cambridge.	----	----	13.48	13.33	13.21	13.22	13.37	13.45	13.49	13.39	13.14	12.79
New Haven.	----	----	13.47	13.40	13.25	13.11	13.20	13.33	13.41	13.41	13.29	13.05
New York.	----	----	13.56	13.51	13.39	13.27	13.32	13.36	13.36	13.31	13.19	12.99
Sandy Hook.	----	----	13.70	13.59	13.36	13.17	13.23	13.35	13.40	13.39	13.30	13.13
Albany.	----	----	13.68	13.65	13.72	13.80	13.87	13.93	13.92	13.82	13.61	13.27
Average, type I.	----	----	13.58	13.50	13.39	13.31	13.40	13.48	13.52	13.46	13.31	13.05
Philadelphia.	----	----	13.52	13.44	13.45	13.47	13.51	13.55	13.58	13.57	13.49	13.25
Baltimore.	----	----	13.56	13.45	13.38	13.37	13.44	13.46	13.48	13.48	13.38	13.22
Washington.	----	----	13.43	13.36	13.31	13.34	13.39	13.42	13.42	13.38	13.29	13.20
Toronto.	----	----	14.03	13.93	13.95	13.91	13.82	13.82	13.77	13.78	13.78	13.76
Cleveland.	----	----	13.85	13.78	13.76	13.75	13.78	13.83	13.84	13.81	13.74	13.61
Detroit.	----	----	13.85	13.80	13.71	13.68	13.72	13.75	13.76	13.78	13.73	13.62
Average, type II.	----	----	13.71	13.63	13.59	13.59	13.61	13.64	13.64	13.63	13.57	13.44

The two type-curves are shown in a preceding illustration in connection with the curves for the dip, and their comparison indicates the preponderating influence of the change of the latter over the change in the horizontal force.

At any place where  $H$ ,  $dH$ ,  $\theta$ , and  $d\theta$  are known, the annual change in  $F$  can be computed by  $dF = \sec \theta dH + F \tan \theta d\theta$ , in absolute measure, or by  $\frac{dF}{F} = \frac{dH}{H} + \tan \theta d\theta$  expressed in parts of the force; similarly the annual change  $dV$  of  $V$  may be computed by  $dV = H \sec^2 \theta d\theta + \tan \theta dH$  and  $\frac{dV}{V} = \frac{d\theta}{\sin \theta \cos \theta} + \frac{dH}{H}$ , when expressed in parts of the vertical component.

#### SECULAR VARIATION OF THE DIRECTION OF A FREELY SUSPENDED MAGNETIC NEEDLE.

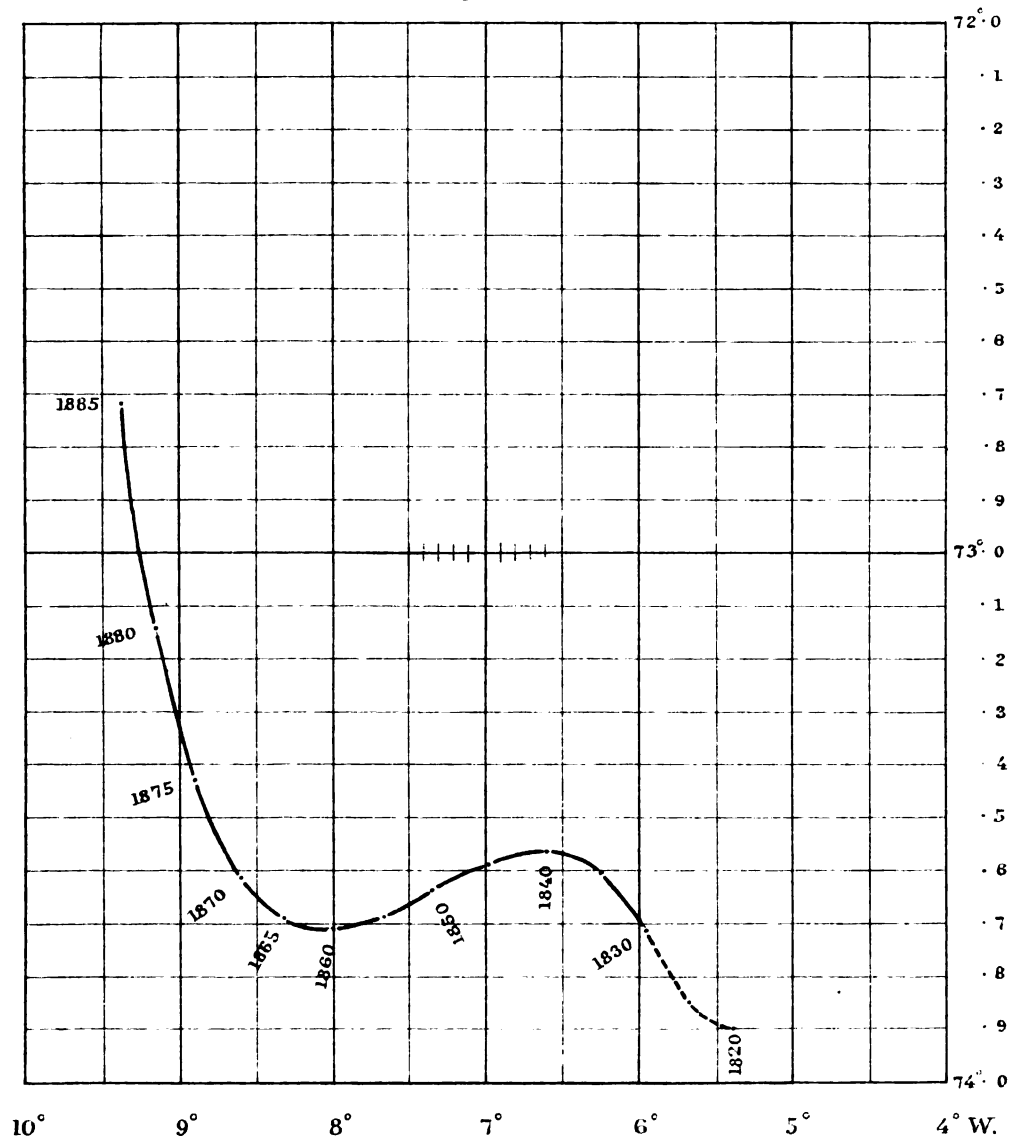
Quite an instructive diagram may be constructed by combining the secular variations of the declination and of the dip so as to show the actual secular motion of the direction of a magnetic needle when *freely* suspended.\*

Conceive a sphere described with any convenient radius about the center of gravity of the needle, and suppose that portion of its *inner* surface viewed (from the center) toward which the north end of the needle may be pointing. Producing the direction of the north end of the needle, as observed at any given epoch, it will intersect the sphere in a given point, and a series of such points will be had if this be repeated for a number of epochs. A curve freely drawn through these consecutive points will then represent the actual secular motion in the direction of the needle, and may be projected on a plane, tangent to the sphere at a point near the middle of the region.

For our illustration we select the group of northeastern stations and designated as type I, the average geographical position for which corresponds approximately to central Connecticut. The dips for each fifth year have already been given; the corresponding declinations were taken from

\* A similar diagram was recently employed by Dr. W. Schaper to exhibit the complete *hourly* variations of the needle at Lübeck for December 23, 1884.

*Secular Variation in the Direction of a freely suspended  
magnetic Needle for the Period 1820 to 1885.  
(New England States.)*





the Coast and Geodetic Survey Report for 1882, Appendix No. 12, either directly from the table for each tenth year or by computation (using the formulæ given on page 258). The values are given below, the plus sign being omitted (denoting west declination), as applying to all:

Stations.	(Jan. 1), 1825.	1830.	1835.	1840.	1845.	1850.	1855.	1860.	1865.	1870.	1875.	1880.	(Jan. 1), 1885.
Cambridge.	° 8.32	° 8.64	° 8.98	° 9.33	° 9.69	° 10.03	° 10.36	° 10.67	° 10.96	° 11.21	° 11.44	° 11.63	° 11.78
New Haven.	5.17	5.39	5.65	5.95	6.27	6.61	6.97	7.35	7.72	8.10	8.47	8.84	9.19
New York.	4.63	4.88	5.20	5.56	5.94	6.31	6.64	6.93	7.18	7.40	7.60	7.81	8.03
Sandy Hook.	4.26	4.51	4.83	5.19	5.57	5.94	6.27	6.56	6.81	7.03	7.23	7.44	7.66
Albany.	6.06	6.35	6.66	7.00	7.36	7.74	8.11	8.49	8.86	9.23	9.57	9.90	10.19
Average, type I.	5.69	5.95	6.26	6.61	6.96	7.33	7.67	8.00	8.31	8.59	8.86	9.12	9.37

Suppose radius of sphere = 4 m., one degree of a great circle would have the length  $\frac{4}{57.3}$  nearly, or 6.98 cm., and one degree of a parallel for average dip of  $73^\circ$  would equal  $6.98 \cos 73^\circ$ , or 2.04 cm. The diagram is constructed accordingly; \* the degrees marked on the right-hand margin are those of the dip, *diminishing* upwards; the degrees marked at the bottom are those of the declination, *increasing* to the left or *westward*.

Plotting the typical values of dip and declination for every fifth year between 1830 and 1885, and uniting the points so obtained by a free-hand curve, we have the representation of the secular motion of a freely suspended needle, as shown in the accompanying diagram. The dotted part between 1820 and 1830 is doubtful, only one of the coördinates being known with certainty. In its further extension into past time the curve is known to be a tangent to the vertical line of  $40.9$  in or about the year 1794 (see Table III of Appendix 12, Report for 1882), and it is here where we regret most the total absence of information respecting the state of the dip, and which debars us from even conjecturing the course of the curve during the past century, though it lies wholly to the westward of the vertical touched in 1794.

The secular variation in the total intensity might also be indicated in the diagram by variation in the thickness of the curve. The change, however, is of a very simple nature, and it suffices to state that since about 1870 the magnetic force has been rapidly declining in intensity.

#### CONSTRUCTION OF ISOMAGNETIC MAPS OF THE UNITED STATES, SHOWING THE DISTRIBUTION OF THE DIP AND OF THE HORIZONTAL COMPONENT AND TOTAL VALUE OF THE EARTH'S MAGNETIC INTENSITY, FOR THE EPOCH JANUARY 1, 1885.

It is not our purpose to review here in particular any one of the isomagnetic maps that have been constructed from time to time since the production of the first *isoclinic* map by Wilke, in 1768, and the first *isodynamic* map by Humboldt, which was based upon his American observations, made between 1799 and 1804; but we shall briefly refer to some maps more specially related to the United States or covering parts of its territory.

We need but mention, as claiming now but little attention in consequence of their necessary imperfections, the isoclinic maps published by Hansteen in the first quarter of the present century. That for the epoch 1600 is based on the dip observations of Hudson and Baffin; that for 1700 on observations of Cunningham, Feuillée, La Caille, and Ekeberg; that for 1780 on observations by Cook and La Perouse. Gauss, in his great work on the General Theory of Terrestrial Magnetism, obtains his data for the inclination mainly from Horner's map (date about 1827), and for the intensities (total) from the admirable map published by Major E. Sabine (Report of the Seventh Meeting of the British Association for the Advancement of Science, Vol. VI, London, 1838). No strict reduction to a fixed epoch was then practicable, and the results group themselves, on the average, near or before the year 1830, as a rough epoch. The maps of the values of the inclination and of the horizontal force, computed according to the theory of Gauss, are contained in Taylor's Scientific Memoirs, Vol. II, Part VII, London, 1841.

\*A gnomonic or central projection might be used with advantage, but for the present the simpler construction answers as well.



In the Philosophical Transactions of the Royal Society for 1840 Major Sabine gives two charts, entitled "Magnetic Isoclinical Lines in the Atlantic, 1837," and "Magnetic Isodynamic Lines in the Atlantic, 1837." The first of these special charts only reaches the eastern border of the United States. In Silliman's Journal, 1838, Art. III, Prof. E. Loomis laid down the lines of equal dip for every  $5^\circ$  for the eastern part of the United States, but disclaims any great precision for them; again, in Silliman's Journal, Vol. XXXIX, 1840, he gives a map of equal dip for the epoch 1840, with the remark that the lines in the northeastern part are fairly accurate, but those in the southeastern part in a measure conjectural.

Appendix No. 28 of the Coast Survey Report for 1856, by Superintendent A. D. Bache and Assistant J. E. Hilgard, is accompanied by a small map showing for the epoch 1850 the distribution of the inclination and of the horizontal intensity along a narrow strip of our Atlantic, Gulf, and Pacific coasts, and along the Mexican boundary. In the Coast Survey Report for 1862 Superintendent A. D. Bache gives a map of Pennsylvania, showing for the epoch 1842 the distribution of the dip, the horizontal and total intensity for that State.

The contributions to terrestrial magnetism, Nos. XIII and XIV, by General Sir E. Sabine, in the Phil. Trans. Roy. Soc. for 1872 and 1875, contain most valuable maps, forming part of the representation of the magnetic condition of the earth's surface about the epoch 1840-45. Plate XLIX in the volume for 1872 shows the distribution of the inclination on a circumpolar map down to north latitude  $35^\circ$ , and Plate L the distribution of the total intensity within the same limits. To complete the work for the northern hemisphere, Plates Nos. 27 and 28, Phil. Trans. of 1875, exhibit the distribution of these same elements for the zone between north latitude  $40^\circ$  and the equator. On these maps we find marked, besides the curves of definite values, the position and value for each individual station.

The latest published charts are those by General Sir J. H. Lefroy in his "Diary of a Magnetic Survey in Canada, &c.," London, 1883. These are on a comparatively large scale, so as to permit, in regions where the magnetic stations were numerous, the representation of the larger local deflections. The curves, consequently, do not show that symmetry or uniformity which forms so familiar a feature of the older charts. There are four, all for the epoch 1844; the values of the inclination, and of the total intensity are given for each station, with curves for intervals of one degree and of 0.5 (English) units, respectively. Plate V includes the region of our northwestern boundary from Lake Superior to the Pacific, where it extends down to the central latitude of Oregon; Plate VI comprises all that part of the United States lying between the States of Maine, North Carolina, Missouri, and Minnesota.

Notwithstanding the fact that dip observations date back fully three centuries, and relative intensity observations just one century, and that we have absolute measure for a little more than half that time, we cannot utilize all the material here collected for the purpose of giving greater completeness or greater precision to our charts, but must content ourselves with using only those observations which are of *recent date*. Otherwise there would be great liability to error in consequence of defective reduction to epoch, our present knowledge of the secular variation being inadequate in range and amount. In regions where we have imperfect or no knowledge of the secular change of either element the fact is indicated in their graphical representation by dotted lines, and in the tabular statement it is indicated by the result being given with one place of decimals less than the usual number. Numbers within parentheses were not used at all, these results having been recognized as defective. The observations in the Territory of Alaska are yet too scanty for satisfactory charting. For the plotting of the positions and observed values of the stations on the three maps I am indebted to Mr. A. Ziwet, of the Computing Division.

Upon the whole, the representation of the dip for the epoch 1885 is far more satisfactory than the representation of the horizontal intensity for the same epoch, and it appeared plain enough that the cause was to be found in defective determination of the instrumental constants required for the latter measure.

In conclusion, we regard the compilation and discussion of the magnetic dips and intensities herewith presented as of more permanent value than the mere reduction to epoch and their charting, which latter operations may be much better performed after the lapse of some years, when the law of secular variation shall have become better understood.

## APPENDIX No. 7.

### COLLECTION OF SOME MAGNETIC VARIATIONS OFF THE COASTS OF CALIFORNIA AND MEXICO, OBSERVED BY SPANISH NAVIGATORS IN THE LAST QUARTER OF THE EIGHTEENTH CENTURY.

Communicated by GEORGE DAVIDSON, Assistant.

This paper contains excerpts from the logs of certain Spanish vessels which sailed from the ports of San Lucas, Lower California, and San Blas, Mexico, in the years 1774 to 1790, giving the magnetic variation at different parts of the voyage.

The notes are from an English manuscript translation of a Spanish manuscript copy of the original documents. There is no mention, as far as seen, of the way in which the variations were obtained, nor any explanation of the asterisk (\*) which distinguishes some of them.

These documents in Spanish are copies of the manuscript documents in the State Department at Washington, and were furnished to me some years since. Those in the State Department were copied from the archives at Madrid pending the question of the northwest boundary of the United States.

The tabulation is made only on those dates when the variation appears in the proper column, and I suspect that some of the given variations are interpolated, unless we suppose that they as regularly observed the sun for azimuth as for position. I think it probable that the star (\*) to an observation means that the azimuth was determined from observations on a star instead of the sun.

The notes as to seeing land, &c., will in a rough way check the longitudes, which are crude at the very best; in one case they found themselves 9° in error, but the landfall checks it. I am indebted to Assistant C. A. Schott for filling in the column headed "Longitude west from Greenwich." He assumed for the longitude of San Lucas — 109° 54', and for the longitude of San Blas — 105° 17', with a probable uncertainty of  $\pm 0.5$ , and the figures given are those resulting from the addition or subtraction (as the case may be) of the differential values of the preceding column to or from one or the other of these absolute longitudes.

GEORGE DAVIDSON.

#### *Voyage of frigate Santiago for discovery of north coast of California.*

[Commander Don Juan Berez, lieutenant of the Royal Navy.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Vari- ation north- east.	Remarks.
1774.	° /	° /	° /	° /	Left San Blas 25th.
Jan. 31	20 45	3 54	113 48	5 00	[Off Lower California—Sch.]
Feb. 1	20 29	3 32	113 26	5 00	
June 26	35 37	21 45	131 39	5 00	
29	37 20	24 35	134 29	10 19*	
July 1	39 43	26 08	136 02	7 42*	
Aug. 9	48 17	15 17	125 11	18 18	Saw land at great distance. [Off Cape Flattery—Sch.]
15	42 37	14 26	124 20	5 30	Coast not visible. [Supposed should be 15° 30'—Sch.]
21	39 46	----	----	11 15	Cape seen; thought to be Mendocino. [Probably Point Delgado $\lambda = -124^{\circ} 15'$ —Sch.]
Oct. 10	36 48	13	123	11 00	[Off Santa Cruz—Sch.]
12	36 14	12 03	121 57	11 00	[Off Point Sur—Sch.]

*Frigate Santiago and schooner Sonora.*

[Commander Don Bruno de Heceta.]

Date.	Lat. north.	Long. west of San Blas.	Long. west from Greenwich.	Variation north-east.	Remarks.
1775. Mar. 16	21 25	5 00 <i>Long. west of San Lucas.</i>	110 17	4 30	[Off Cape San Lucas—Sch.]
25	20 35	4 02	113 56	4 30*	
26	20 10	2 58	112 52	4 30*	
27	19 49	0 50	110 44	5 00	[Near Socorro Island—Sch.]
Apr. 1	18 33	0 37	110 31	5 00	
2	18 33	0 48	110 42	5 13*	
23	21 21	15 15	125 09	6 00	
30	25 57	21 22	131 16	7 00	
May 1	26 31	22 07	132 01	7 00	
11	32 10	27 50	137 44	8 00	
31	37 59	21 35	131 29	10 00	
June 1	38 14	21 12	131 06	10 00	
2	39 30	20 26	130 20	12 00	
4	40 13	18 35	128 29	10 30*	
7	41 45	15 19	125 13	14 00	} [Off Point St. George—Sch.]
8	41 31	14 53	124 47	14 30*	
20	40 59	14 21	124 15	14 00	[Off Trinidad—Sch.]
26	39 20	20 40	130 34	13 00	
July 2	42 15	21 49	131 43	14 00	
6	44 14	20 47	130 41	15 00	
7	46 10	21 06	131 00	16 00	
10	47 35	18 28	128 22	17 00	
13	47 28	16 34	126 28	17 00	
15	47 23	16 40	126 34	17 30*	
18	46 32	18 32	128 26	16 00	
23	45 41	24 24	134 18	15 00	
27	47 05	24 59	134 53	16 00*	
Aug. 6	47 04	18 55	128 49	18 00*	[Off coast of Washington Terr.; probably in $\lambda = -128^{\circ} 30'$ —Sch.]
9	49 11	18 35	128 29	19 00*	[Off Vancouver Island, probably in $\lambda = -128^{\circ} 00'$ —Sch.]
11	49 42	18 35	128 29	18 00*	In sight of land. [Probably in $\lambda = -128^{\circ} 00'$ —Sch.]
17	46 15	15 38	125 32	17 00*	In sight of entrance, called Hecata. [Off Cape Disappointment, mouth of Columbia River, corrected long. $\lambda = -124^{\circ} 20'$ —Sch.]
21	42 25	15 09	125 03	17 00	
27	37 54	14 30	124 24	16 00	[Off Punta Reyes, probably in $\lambda = -123^{\circ} 20'$ —Sch.]
Aug. 1	46 34	25 56	135 50	16 00	Observations on schooner.
9	49 09	29 07	139 01	17 00	
10	50 18	29 54	139 48	18 00	
13	53 54	31 07	141 01	19 00	
15	56 08	29 47	139 41	19 00	
22	57 57	33 03	142 57	20 00	
23	57 08	30 50	140 44	22 00*	
24	56 01	28 46	138 40	24 00*	
28	55 36	29 39	139 33	23 00*	
Sept. 6	54 42	31 27	141 21	22 00	

*Frigate Santiago and schooner Sonora.—Continued.*

[Commander Don Bruno de Heceta.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Variation north-east.	Remarks.
1775.	° /	° /	° /	° /	
Sept. 7	54 53	31 56	141 50	23 00	
9	54 32	30 22	140 16	22 00	
10	54 06	30 10	140 04	21 00	
12	52 00	26 54	136 48	20 00	
18	47 50	19 05	128 59	19 00	
25	44 19	16 02	125 56	18 00*	Off Cape Orford or Blanco.
27	42 37	16 41	126 35	17 00	In sight land. [Probably in $\lambda = -124^{\circ} 34' - \text{Sch.}$ ]
30	39 42	16 11	126 05	16 00	In sight coast. [Off Point Delgado, Shelter Cove; probably in $\lambda = -124^{\circ} 15' - \text{Sch.}$ ]
Oct. 6	37 43	14 14	124 08	15 00	[Off Punta Reyes, probably in $\lambda = -123^{\circ} 45' - \text{Sch.}$ ]
7	36 42	13 47	123 41	14 00	[Off Bay of Monterey, probably in $\lambda = -123^{\circ} 15' - \text{Sch.}$ ]

*Sr. Virey and Antonio Bucareli.*

[Commanding two frigates, Exp'n of 1779.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Variation north-east.	Remarks.
1779.	° /	° /	° /	° /	
Feb. 27	20 33	2 27	112 21	5 00	[Off Socorro—Sch.]
Mar. 1	20 21	9	110 03	5 30	
4	20 00	1 40	111 34	6 00*	
9	20 08	6 57	116 51	7 00	
15	22 00	13 02	122 56	8 00	
22	24 54	18 52	128 46	9 00	
26	28 01	22 53	132 47	9 30	
30	30 10	25 19	135 13	10 00	
Apr. 4	31 29	28 14	138 08	11 00	
10	34 23	30 16	140 10	11 30	
13	36 03	31 51	141 45	12 00	
14	37 19	32 04	141 58	13 00	
16	39 25	31 50	141 44	14 00	
20	42 58	30 28	140 22	15 00	
24	48 30	30 46	140 40	16 00	
25	49 25	30 40	140 34	17 00	
26	51 06	31 20	141 14	18 00	
27	53 14	32 00	141 54	19 30	
28	55 01	31 57	141 51	21 00	
29	55 15	31 33	141 27	22 30	
May 2	55 22	27 03	136 57	23 30*	
July 2	54 16	28 02	137 56	23 30	
3	53 23	28 49	138 43	22 30	
4	53 33	29 03	138 57	22 00	

*San Virey and Antonio Bucareli.—Continued.*

[Commanding two frigates, Exp. of 1779.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Variation north-east.	Remarks.
1779.	° /	° /	° /	° /	
July 5	54 36	30 22	140 16	22 30	
6	55 23	31 25	141 19	23 00	
7	56 13	31 58	141 52	23 30	
8	57 21	33 28	143 22	24 00	
9	58 05	33 51	143 45	25 30	
10	58 26	34 03	143 57	26 00	
18	59 48	38 21	148 15	26 30*	
29	59 35	40 32	150 26	26 00	
Aug. 9	57 59	42 13	152 07	27 00*	
11	57 25	40 06	150 00	26 00	
17	56 36	34 25	144 19	25 30	
19	55 17	30 54	140 48	24 30	
20	55 09	30 18	140 12	23 30	
21	54 36	29 23	139 17	23 00	
22	54 12	28 20	138 14	22 30	
23	52 39	28 00	137 54	21 30	
24	51 16	26 53	136 47	20 00	
25	50 46	26 26	136 20	19 30	
26	49 39	25 42	135 36	19 30	
27	49 03	25 11	135 05	19 00	
28	48 38	24 42	134 36	18 30	
29	48 01	24 06	134 00	18 00	
30	46 40	23 09	133 03	17 30	
31	46 27	21 56	131 50	16 30	
Sept. 1	45 19	20 32	130 26	16 30*	
2	43 45	18 52	128 46	16 00	} [Off coast of Oregon—Sch.]
3	42 03	16 56	126 50	15 30	
4	40 56	15 32	125 25	15 00	} [Off coast of California—Sch.]
5	39 39	14 31	124 25	14 00	
6	39 28	14 42	124 36	13 30	} [Off Punta Arena—Sch.]
10	38 56	14 04	123 58	13 00	
Oct. 31	37 36	13 17	123 11	13 00	[Near the Farallon Islands—Sch.]
Nov. 1	37 10	13 12	123 06	12 30	[Off Halfmoon Bay—Sch.]
2	36 02	12 43	122 37	12 00	[Off Point Sur—Sch.]
3	34 51	12 19	122 13	11 00	[Off San Louis Bay—Sch.]
6	30 56	9 57	119 51	10 30	
7	29 46	9 02	118 56	10 00	[Off Lower California, Mexico—Sch.]
8	28 17	7 33	117 27	9 30	
9	27 05	6 37	116 31	8 30	
10	26 06	5 39	115 33	7 30	
11	25 17	4 45	114 39	7 00	
14	23 02	1 08	111 02	6 30	
15	22 50	0 14	110 08	6 00	On the 15th they found themselves in the neighborhood of Cape San Lucas, and on standing in found that their point was only four leagues to the east of the demarcation of the Cape; made at 6 p. m. west longitude.

*Sr. Virey and Antonio Bucareli.—Continued.*

[Commanding two frigates, Exp'n of 1779.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Variation north-east.	Remarks.
1779. Nov. 16	° / 22 31	° / 0 38	° / 110 32	° / 5 30	
18	21 49	3 38	113 32	5 00	

[Same for frigate Favorita.]

1779. Feb. 27	20 34	1 52	111 46	5 00	[Off Socorro—Sch.]
Mar. 2	20 26	4 35½	114 29	6 00	[Off Santa Rosa—Sch.]
8	20 11	10 15	120 09	7 00	
13	21 12	15 56	125 44	8 00	
22	24 50	23 12	133 06	9 00	
26	28 11	26 51½	136 45	9 30	
31	30 18	30 19	140 13	10 00	
Apr. 7	32 58½	32 24	142 18	11 15	
12	35 59	35 32½	145 26	12 00	
14	38 57½	36 01	145 55	14 00	
21	44 56	33 50½	143 44	15 00	
22	46 11½	33 24½	143 18	15 30	
23	48 36	33 38	143 32	16 00	
24	49 21	34 24	144 18	17 30	
25	51 04	34 20	144 14	18 00	
26	53 14	35 05	144 59	19 30	
27	51 01	35 46	145 40	21 15	
28	55 13	35 46	145 40	22 30	
29	55 31	35 08	145 02	23 30	
May 2	55 15	31 53	141 47	25 00	Difference in the standing in to the shore up to hour of casting anchor, 45' in longitude farther east.
July 2	54 15½	32 55	142 49	22 00	
5	54 32	35 10½	145 04	22 30	
6	55 19	36 12	146 06	23 00	
8	57 15	38 15	148 09	24 30	
9	58 06	38 47	148 41	25 30	
10	58 29	38 45	148 39	26 00	
13	58 12	39 39½	149 33	25 30	
14	58 07½	39 58	149 32	26 00	
17	59 46	42 01½	151 55	26 30	
18	59 47	43 23	153 17	27 00	
19	59 56	43 51½	153 45	25 30	
Aug. 8	58 42	47 30	157 24	25 00	
9	57 58	46 42½	156 36	25 30	
10	57 57½	46 20	156 14	27 00	
16	57 52	40 14	150 08	26 00	
18	56 11	38 43	148 37	25 30	
19	55 55½	37 03	146 57	24 00	
20	55 08	35 15	145 09	23 00	

*Sr. Virey and Antonio Bucareli.—Continued.*

[Commanding two frigates, Exp'n of 1779.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Vari- ation north- east.	Remarks.
1779.	° /	° /	° /	° /	
Aug. 21	54 34½	34 35	144 29	23 00	
22	54 11	33 45	143 39	22 30	
23	52 37	33 02½	142 56	21 30	
24	51 16	32 19	142 13	20 00	
25	50 47	31 13	141 07	19 30	
26	49 40	30 43	140 37	19 00	
27	49 03½	29 55	139 49	19 00	
28	48 37½	29 24	139 18	18 30	
29	48 00	28 55	138 40	18 00	
30	47 24	28 20½	138 14	17 00	
31	46 25	27 22½	137 17	16 30	
Sept. 1	45 17½	26 09	136 03	16 00	
2	43 44	24 45	134 39	16 54	
3	42 03	23 07	133 01	15 30	[Detective longitudes—Sch.]
4	40 54	21 10	131 04	14 30	
5	39 38	19 46	129 40	14 00	
6	39 26	19 54	129 48	13 30	
9	38 59	19 25½	129 19	13 00	
14	37 49	19 00	128 54	13 00	San Francisco, [Corrected longitude $\lambda = -122^{\circ} 45'$ —Sch.]
Oct. 31	37 35	18 14	128 08	13 00	
Nov. 2	36 01	17 40	127 34	12 30	
3	34 50	17 16	127 10	12 00	
4	33 50	16 45	126 39	11 30	
5	32 02	15 47	125 41	11 00	
6	30 35	14 54	124 48	11 00	
7	29 40	13 59	123 53	10 30	
8	28 16	12 30	122 24	10 00	
9	27 04	11 33	121 27	9 30	
10	26 25	10 36	120 30	8 30	
11	25 16	9 42	119 36	7 30	
12	24 22	8 38	118 32	7 00	
13	23 27	7 26	117 20	7 00	} [Off Lower California—Sch.]
14	23 01	6 06	116 00	6 30	
15	22 49	5 13	115 07	6 00	
16	22 30	4 24	114 18	5 30	
17	22 16	2 46	112 40	5 30	
18	21 48	1 32	111 26	5 00	
19	21 37	0 54	110 48	5 00	
20	21 33	0 26	110 20	5 00	[Off San Lucas—Sch.]

*Voyage of 1788, in vessels Princessa and San Carlos, northern coast of California.*

[Princessa commanded by Ensign of the Navy Don Esteban Martinez, and San Carlos by First Mate Don Gonzalo Lopez de Haro. Vessels sailed on the 8th of March, 1788, from port of San Blas, situated under latitude  $21^{\circ} 30'$ , and  $107^{\circ} 6'$  to west of Paris ( $104^{\circ} 46'$  to west of Greenwich), and  $5^{\circ}$  to east of Cape San Lucas, in the peninsula of California.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Variation north-east.	Remarks.
1788.	° /	° /	° /	° /	
Mar. 9	21 30	5 00†	104 54	5 00	[† Probably east of San Lucas, near San Blas.—SCH.]
18	20 14	2 50	112 44	5 30	[Off Lower California.—SCH.]
19	20 16	3 55	113 49	5 30*	
23	20 25	6 44	116 38	6 00*	
24	20 38	7 51	117 45	6 00	
28	21 38	12 12	122 06	7 00	
29	21 58	13 30	123 24	8 00	
30	22 39	14 58	124 52	8 00	
31	23 16	16 18	126 12	7 37*	
Apr. 2	24 06	18 16	128 10	8 00*	
3	24 27	19 04	128 58	8 30	
6	26 46	22 23	132 17	9 00	
9	28 32	25 11	135 05	10 00*	
15	30 54	29 36	139 30	11 22*	
18	34 55	30 17	140 11	12 00	
21	36 32	31 24	141 18	12 00	
22	37 37	31 46	141 40	13 00	
23	39 07	31 58	141 52	16 08	
27	42 40	32 39	142 33	17 47*	
28	43 23	33 03	142 57	18 30	
29	44 23	33 10	143 04	19 00	
30	45 53	32 49	142 43	19 30	
May 2	48 09	32 26	142 20	20 13*	
4	51 20	33 24	143 18	21 00	
7	53 31	31 59	141 53	22 00	
13	56 21	35 30	145 24	23 00	
15	58 37	36 44	146 38	24 00	Mount St. Elias, north-east one-fourth north.
17	60 10	37 41	147 35	25 00	
19	59 49	37 09	147 03	25 00	
23	59 35	38 43	148 37	26 00	
Aug. 24	53 18	53 20	163 14	22 30	
27	52 33	46 51	156 45	22 00	
28	52 03	45 08	155 02	21 00	
Sept. 1	49 46	33 04	142 58	20 00	
4	47 08	26 55	136 49	19 00	
8	42 15	22 23	132 17	18 00	
9	41 28	21 06	131 00	17 00	
13	40 03	15 38	125 32	16 00	[Off Point Delgado.—SCH.]
Oct. 17	36 32	9 24	119 18	14 00	
20	35 17	9 11	119 05	13 00	[Doubtful longitude.—SCH.]
Nov. 17	33 19	7 13	117 07	12 00	
19	33 27	7 58	117 52	11 00	[Near San Pedro.—SCH.]



*Voyage of 1788, in vessels Princessa and San Carlos, northern coast of California.—Continued.*

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Vari- ation north- east.	Remarks.
1788. Nov. 21	° / 29 45	° / 6 26	° / 116 14	° / 10 00	[Off San Geronimo.—SCH.]
24	25 43	2 41	112 35	9 00	
25	24 37	1 42	111 36	7 00	[Near Santa Maria Bay.—SCH.]
27	23 48	0 27†	109 27	6 30	† East. [Near Cape Punta Arenas.—SCH.]

*Voyage of the packet San Carlos from Ounalaska to San Blas (coincidentally with frigate Princessa).*

Aug. 28	54 02	54 06	164 00	19 00	
31	51 26	48 39	158 33	18 43*	
Sept. 2	51 58	45 32	155 26	19 00	
5	51 23	37 34	147 28	18 30	"The 4th, at 10 p. m., the horizon was illuminated as if it were the moon in opposition; at 10¼ commenced to diminish from the west. That day there were seen several signs of land."
7	50 54	31 27	141 21	18 00	
10	48 25	24 48	134 42	17 00	
14	42 37	23 46	133 40	16 00	
16	42 08	23 36	133 30	16 30	
18	42 01	22 23	132 17	16 00	
20	41 08	20 08	130 02	13 00*	
21	40 20	20 20	130 14	12 30	
22	39 12	19 23	129 17	12 00	
23	38 13	17 52	127 46	11 30	
24	37 06	16 41	126 35	11 00	
25	36 11	15 30	125 24	10 30	[Off Monterey.—SCH.]
26	35 15	14 18	124 12	10 00	
29	32 38	10 56	120 50	9 00	
Oct. 1	31 44	8 46	118 40	8 30	[Off San Diego.—SCH.]
3	30 37	6 28	116 22	8 00	
7	28 16	9 10	119 03	6 53	"Saw island of Guadalupe, and, according to calculations observed, it was found in 9° 19' of longitude west of San Lucas. This island is 143 leagues, with eastern projection in the same situation as the vessel, so that they found, according to their reckoning, a greater longitude between Ounalaska and Guadalupe than that which is assigned to it; but this calculation is doubtless very erroneous."
8	28 16	9 19	119 12		
8	27 04	7 07	117 01	6 00*	
9	25 43	5 18	115 12	5 00	
10	25 01	4 41	114 35	5 30	
11	24 43	4 21	113 55	5 20	
12	24 12	3 36	113 30	5 10	
13	23 37	2 53	112 47	5 00	
16	22 53	† 1 13	108 41	5 00	[† East. "This day they saw Cape San Lucas, which was found in 93° longitude, between the demarkation and its point."
17	22 43	1 17	108 37	4 28	[Off Mazatlan and San Blas.—SCH.] "This day they found themselves in the vicinity of Santa Maria Islands, and anchored southward of them, at San Blas, on the 22d."
18	22 15	2 45	107 09	4 28	
19	21 56	4 08	105 46	4 28	

*Voyage from San Blas to Nutka, 1790.*

[The 13th of February, 1790, there set sail from the port of San Blas, situated in  $21^{\circ} 30'$  latitude, and to the east of San Lucas  $5^{\circ}$ , or, what is the same, to the west of Paris  $107^{\circ} 06'$  (west of Greenwich  $104^{\circ} 46'$ ), the three vessels of the King—frigate *Concepcion*, commanded by the Lieutenant of the Navy Don Francesco Eliza, commandante of the expedition; the packet *San Carlos*, commanded by Lieutenant Don Salvada Fidalgo; and sloop *Princess Royal*, commanded by Naval Ensign Don Manuel Quimper.]

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich,	Variation north-east.	Remarks.
1790. Feb. 6	21 13	3 40†	106 14	6 00	[† Supposed east of San Lucas. Off San Blas.—SCH.] Passed short distance to south Santa Maria Islands. [Off Lower California.—SCH.]
13	20 29	4 15	114 09	6 55	
15	20 09	5 59	115 53	6 49	
19	21 41	10 49	120 43	7 00	
21	22 29	13 50	123 44	7 30	
22	23 08	15 26	125 20	8 00	
26	27 08	20 27	130 21	8 30	
Mar. 2	30 07	23 12	133 06	9 00	
4	31 00	25 20	135 14	9 30	
6	33 37	27 41	137 35	10 00	
7	34 55	27 48	137 42	10 30	This day land was seen distant 8 or 9 leagues.  Anchored in 35 fathoms of water 2 leagues from the coast, the Point Boisset bearing towards them from the west $\frac{1}{4}$ northwest, $3^{\circ}$ west. [Position to the north and west of Nootka, Vancouver Island.—SCH.]
8	35 30	27 29	137 23	11 00	
13	40 10	27 20	137 14	11 30	
24	49 46	22 35	132 29	17 30	
25	49 56	21 30	131 24	18 09	
27	49 55	17 41	127 35	17 46	

*Record of the packet Philipino, commanded by Fidalgo, in his voyage of discovery, in 1790, from Nutka to Prince William, Cook's River, and return to Monterey.*

May	4					Set sail from Nutka.	
	5	48 59	18 03	127 57	17 04	} [Off Vancouver Island.—SCH.]	
	6	48 41	18 30	128 24	18 00		
	7	49 00	18 56	128 50	18 30		
	12	47 03	22 58	132 52	17 30		
	17	51 48	33 42	143 36	20 13		
	20	56 33	35 17	145 11	22 30	The 23, at noon, land was seen, being northwest point of Prince William, so that their reckoning agreed exactly with the true longitude. [Off Port Etches.—SCH.]	
	23	60 12	36 37	146 31	26 00		
July	1	59 38	39 18	149 12	25 00		
	10	58 10	42 13	152 07	22 10	Camacho Island in sight.	
	19	58 32	39 10	149 04	24 00		
	25	56 33	35 04	144 58	23 00		
		[Then several apparent approximations, and]					
Aug.	9	37 35	13 28	123 22	14 30	They found themselves at the Farallones, off San Francisco, and consequently in latitude 37° 36', and to the west of San Lucas 13° 22', their real position according with the reckoning.  On the 25th they departed from that port, which is in latitude 36° 42', and 17° west of San Lucas.	
		[Daily journal to Monterey, and then following record from Monterey to San Blas.]					
Oct.	27	35 17	13 06	123 00	12 00		
	28	32 45	11 54	121 48	11 00		

*Record of the packet Philipino, commanded by Fidalgo, in his voyage of discovery, in 1790.—Continued.*

Date.	Lat. north.	Long. west of San Lucas.	Long. west from Greenwich.	Variation north-east.	Remarks.
1790.	° /	° /	° /	° /	
Oct. 29	31 02	10 30	120 24	9 00	
30	29 23	9 22	119 16	8 30	
Nov. 4	24 50	5 38	115 32	8 00	To-day they came in sight of the Farallones of Aligos.
6	23 45	4 13	114 07	9 00	
7	23 07	2 28	112 22	8 30	
9	22 41	1 31	111 25	7 30	
10	22 46	1 52†	108 02	7 00	[†Probably east of San Lucas.—SCH.]
11	22 43	2 53	107 01	6 00	
12	22 30	3 39	106 15	5 00	To-day they came between the Santa Maria Islands and the coast.
14	21 30	5 00	104 54		West Cape San Lucas; anchored at San Blas.

*Sloop Princess Royal, voyage from Santa Cruz to Straits of Fuca, year 1790, commanded by Don Manuel Quimper.*

Aug. 6	48 11	15 15	125 09	18 00	[Off Vancouver Island.—SCH.]
7	48 17	15 18	125 12	17 00	
8	48 26	16 30	126 24	15 00	
9	48 54	16 59	121 53	15 30	
10	49 30	17 21	127 15	16 00	
12	49 39	17 50	127 44	17 00	
17	48 48	19 17	129 11	16 30	
20	44 53	18 28	128 22	15 30	
23	43 11	18 02	127 56	15 00	
29	41 20	16 03	125 57	14 30	
30	39 22	15 31	125 25	13 45	The Farallones of Straits of Fuca were seen 8 leagues farther to the east than the reckoning.
31	37 32	13 46	123 40	13 20	
Sept. 1	37 07	12 34	122 28	13 00	

G. D.

## APPENDIX No. 8.

GEOGRAPHICAL POSITIONS OF TRIGONOMETRICAL POINTS IN THE STATES OF MASSACHUSETTS AND RHODE ISLAND, DETERMINED BY THE UNITED STATES COAST AND GEODETIC SURVEY BETWEEN THE YEARS 1835 AND 1885, AND INCLUDING THOSE DETERMINED BY THE BORDEN SURVEY IN THE YEARS 1832 TO 1838.

### INTRODUCTION AND EXPLANATION OF THE TABLE OF POSITIONS.

By CHARLES A. SCHOTT, Assistant.

The geographical positions herewith presented are located in the States of Massachusetts and Rhode Island, and are the results to date of the computation and final adjustment of the primary and subordinate triangulations carried on by the United States Coast and Geodetic Survey between the years 1835 and 1885; to these have been added the results from a recomputation of the earlier triangulation, executed by Mr. Simeon Borden, by authority of the State of Massachusetts, between the years 1832 and 1838, and comprising all of his principal points, the records of many of the subordinate points not having been recoverable.

All results depend on the standard geodetic data of the Survey, viz:

*Unit of length.*—The metre, and in particular the French committee (iron) metre brought here by Superintendent F. R. Hassler; see Appendix No. 7, Coast Survey Report for 1867.

*Surface of reference.*—The spheroid of rotation deduced by Captain A. R. Clarke, R. E., in 1866, as resembling most nearly the earth's size and figure; see comparisons of standards of length, etc., London, 1866; also Appendix No. 7, Coast and Geodetic Survey Report for 1884.

*The standard latitude.*—Is the same as that of the primary triangulation of the Atlantic Coast, viz: Principio  $\phi_0 = 39^\circ 35' 36''.692$ ; see Appendix No. 8, Coast and Geodetic Survey Report for 1879.

*The standard azimuth.*—Is the same as that of the primary triangulation, viz: Principio to Turkey Point  $\alpha_0 = 1^\circ 34' 36''.413$ ; see above report.

*The standard longitude.*—Is the telegraphic longitude of the North American system, depending directly on Greenwich, England, for which see the above report, also Appendix No. 11, Coast and Geodetic Survey Report for 1884. We have for Principio  $\lambda_0 = 76^\circ 00' 16''.407$  west from Greenwich.

The former publications by this office of positions in the two States, in Appendix No. 12, Coast Survey Report for 1851, Appendix No. 15, Coast Survey Report for 1864 and Appendix No. 13, Coast Survey Report for 1868, are therefore superseded, as based upon a different spheroid as well as upon different standard data, nor had these old results been thoroughly adjusted.

Respecting elevations of points above the average tidal level of the Atlantic, their publication must be reserved for a later time, when additional data will be available for a reduction and discussion of the vertical measures of the Survey.

Descriptions of stations can generally be furnished by the office on application.

The method of treatment of the observations by the computer may in general be briefly stated as follows: Starting from the results of the primary triangulation known as the oblique arc of the Atlantic, where the same crosses the boundaries of the States of Massachusetts and Rhode Island, and inclusive of the subordinate primary triangulations of these States, the position of that particular trigonometrical station which is connected *most strongly* with the main triangulation is

first fixed by adjustment, taking into consideration the lines directed to it from primary stations as well as lines diverging from it and intersecting the latter. Should there be more than one such point, say two or more, having equal strength of connection, they are treated together in one least square adjustment. In this manner point after point is adjusted in position, so that the sum of the squares of the corrections to the observed horizontal directions shall be a minimum; — the geometrical relations of the *preceding* points being always considered as fixed with respect to the variable elements of the new point under treatment. The principal secondary stations having thus become known in position, the tertiary positions are determined in the same systematic though somewhat less elaborate manner than that followed for the secondaries, but generally without least square adjustment. The final result of this systematic treatment may be summarized by stating that no discrepancy remains in the results themselves, and that the length and direction of any side of a triangle may be computed from any starting side, and through any series of connecting triangles, and yet the same results will be reached.

The triangulation of the State of Massachusetts by S. Borden was well executed in its time; yet material strength was given to it by the introduction of numerous Coast and Geodetic Survey lines, serving as so many base lines, and by developing the same on Clarke's spheroid with the astronomical standard data of the Coast and Geodetic Survey. Thus modernized and strengthened, it is as serviceable now as then. In consequence of its less perfect measures in the earlier years and in particular covering that part of the triangulation which lies in the vicinity of the base, that length was deduced from the Coast and Geodetic Survey work; but it proved so nearly identical with the result of the direct measure by Mr. Borden that the condition of perfect accord was included in the figure adjustment and satisfied.

The latitudes and longitudes of the trigonometrical points were computed by the usual formulæ, aided by the tables ordinarily employed in the Survey, for which see Appendix No. 7, Coast and Geodetic Survey Report for 1884. For primary sides, not exceeding in length ( $s$ ) 100 or 150 kilometres (about 62 or 93 statute miles), the formulæ for difference of latitude  $\Delta\varphi$ , difference of longitude  $\Delta\lambda$ , and difference of azimuth  $\Delta\alpha$ , are very accurate or sufficiently perfect for the purpose; they are:\*

$$\begin{cases} \Delta\varphi = -s \cdot \cos \alpha \cdot B - s^2 \cdot \sin^2 \alpha \cdot C - (\Delta\varphi)^2 D + h \cdot s^3 \cdot \sin^3 \alpha \cdot E \\ \Delta\lambda = +s \cdot \sin \alpha \cdot \sec \varphi' \cdot A' \\ \Delta\alpha = -\Delta\lambda \cdot \sin \frac{1}{2}(\varphi + \varphi') \sec \frac{1}{2}(\Delta\varphi) - (\Delta\lambda)^2 \cdot F, \end{cases}$$

hence the results for the new position

$$\begin{cases} \varphi' = \varphi + \Delta\varphi \\ \lambda' = \lambda + \Delta\lambda \\ \alpha' = \alpha + \Delta\alpha - 180^\circ \end{cases}$$

For sides not exceeding 25 or 30 kilometres (about 15 or 19 statute miles) the fourth term in the expression for  $\Delta\varphi$  may be omitted, also the factor  $\sec \frac{1}{2}(\Delta\varphi)$  and the second term in the expression for  $\Delta\alpha$ . For full explanation, forms, examples, and auxiliary tables, the reader may consult the Appendix cited above. There also is shown the inverse problem, viz: given  $\varphi$  and  $\lambda$ , and  $\varphi'$  and  $\lambda'$  (or  $\varphi$ ,  $\varphi'$ , and  $\Delta\lambda$ ) to find  $s$ ,  $\alpha$  and  $\alpha'$ . This process may be used in cases where the required distance and azimuths are not implicitly contained in our table of results.

For a direct solution put

$$\begin{cases} s \cdot \cos \alpha = x = -\frac{1}{B}(\Delta\varphi + C \cdot y^2 + D \cdot (\Delta\varphi)^2 + E \cdot \Delta\varphi \cdot y^2 + E \cdot C \cdot y^4) \\ s \cdot \sin \alpha = y = \frac{\Delta\lambda \cos \varphi'}{A'} \end{cases}$$

whence

$$\tan \alpha = \frac{y}{x} \text{ and } s = x \sec \alpha = y \operatorname{cosec} \alpha$$

---

\* With slightly changed notation agreeably to more modern practice.

To facilitate finding stations an alphabetical index for each State is given, and the following subdivisions of the table have been made. There are also appended two sketches showing the triangulations of the two States.

	No. of stations.		No. of stations.
IN MASSACHUSETTS.		IN MASSACHUSETTS.—Cont'd.	
1. Primary stations.	11	16. Massachusetts, New York, and Connecticut Boundary.	15
2. Subordinate primaries and principal secondaries.	20	Connections with surrounding States.	42
3. Nantucket and vicinity.	30	Total.	1162
4. Cape Cod Bay and Peninsula.	144	IN RHODE ISLAND.	
5. Martha's Vineyard and Vineyard Sound.	48	1. Primary stations.	1
6. Buzzard's Bay.	65	2. Subordinate primaries and principal secondaries.	12
7. Boston Bay.	300	3. Sakonnet River and Mount Hope Bay.	43
8. Cape Cod Bay to Boston Bay.	38	4. Providence River.	34
9. Coast north of Cape Ann.	51	5. Narragansett Bay.	116
10. Vicinity of Cape Ann.	39	6. Rhode Island and Massachusetts Boundary.	2
11. Vicinity of Salem.	49	7. Point Judith to Knapp's Point.	76
12. Taunton River.	112	Connections with surrounding States.	30
13. Massachusetts and Rhode Island Boundary.	22	Total.	314
14. Worcester and Middlesex Counties.	10		
15. Connecticut River Valley.	166		

*Other statistical matter:—Observers and years of observation.*

Observer.	Year.	Observer.	Year.
MASSACHUSETTS.		MASSACHUSETTS—Cont'd.	
A. D. Bache.	1844-45-46-47, 1862.	S. C. McCorkle.	1878.
F. Blake, jr.	1877-78.	F. W. Perkins.	1885.
E. Blunt.	1843, 1862-63.	C. H. Sinclair.	1876.
S. Borden.	1832-33-34-35-36-37-38.	W. H. Stearns.	1874.
C. O. Boutelle.	1845-46-47-48-49-50-51, 1860-61, 1867.	J. A. Sullivan.	1875.
C. H. Boyd.	1868.	RHODE ISLAND.	
G. Bradford.	1884.	A. D. Bache.	1844-45.
T. J. Cram.	1848-49.	E. Blunt.	1838-39, 1843-44, 1861.
R. D. Cutts.	1876-77.	S. Borden.	1834-35-36-37.
C. M. Eakin.	1845-46-47, 1849.	G. Bradford.	1884.
G. A. Fairfield.	1877.	C. Hosmer.	1863.
E. Goodfellow.	1870.	S. C. McCorkle.	1868-69-70, 1882.
B. A. Gould.	1864-65.	W. H. Stearns.	1873.
A. M. Harrison.	1876.	J. A. Sullivan.	1871, 1874-75.
C. Hosmer.	1860.	W. H. Swift.	1835.
H. L. Marindin.	1880.		

In Massachusetts there were formed and solved by the computers 3252 triangles (in all), of which 447 belonged to the Borden work. The number (total) of trigonometrical stations occupied is 436; of these 104 belonged to the Borden survey and 39 are common to both surveys. In Rhode Island there were formed and solved 873 triangles, 28 of which were in connection with the Borden survey. 113 trigonometrical stations were occupied in all, 6 belonging to the Borden survey, and

3 are identical in the two surveys. A number of computers were engaged upon this work, but the principal share of the work fell to Mr. E. H. Courtenay, of the Computing Division, to whose zeal, industry, and scrupulous care much of the accuracy of the results is due. The results now communicated were deduced in 1884, 1885, and part of 1886.

Respecting the accuracy of a triangulation the mean error  $m$  of an adjusted or resulting angle has been advantageously employed as a quantity of comparison for different triangulations by which to judge of their relative value (see, *e. g.*, Coast and Geodetic Survey Report for 1884, p. 389). The value  $m$  may be deduced in various more or less accurate ways, according to circumstances; in adjusted triangulations it may be readily deduced from

$$m = 1.25 \sqrt{\frac{2}{n \cdot s}} \cdot \Sigma [c]$$

When  $\Sigma [c]$  is the sum of corrections to observed *directions*,  $n$  the number of conditional equations involved, and  $s$  the number of directions in the adjusted figure, or in unadjusted work, it may be found from

$$m = \sqrt{\frac{\Sigma e^2}{3t}}$$

or, without squaring, from

$$m = 1.25 \frac{[e]}{t \sqrt{3}}$$

where  $e$  = triangle closing error (or difference from  $\pi + \epsilon$ ) and to be taken with positive sign in last formula, and  $t$  = number of triangles. We thus find for the adjusted triangulation of the Coast and Geodetic Survey, but *exclusive* of the primary triangulation, for Massachusetts, the value of  $m = \pm 3''.7$ , and for its unadjusted work  $m = \pm 3''.9$ ; similarly for the Borden survey we find the average values  $\pm 6''.0$  and  $m = \pm 6''.4$  for adjusted and unadjusted work, respectively. For the Rhode Island survey, where the sides are generally short, the average value of  $m$  equals  $\pm 5''.1$

The accuracy of the triangulation may otherwise be roughly expressed in terms of the distance, and thus estimated the average error of secondary work may range between  $\frac{1}{100000}$  and  $\frac{1}{200000}$  of the length, while that of tertiary work may be estimated as low as  $\frac{1}{100000}$  or less near its inferior limit.

There remain but a few words to be added explanatory of the table of results. Column one contains the names of the stations which are located in Massachusetts or Rhode Island, as the case may be, unless otherwise indicated; Borden stations are distinguished by the addition of his name, and stations in common bear the mark C. & G. S. and B.; columns three and five contain the equivalents in metres of the seconds (in arc) of latitude and longitude, respectively, solely for the use of the draughtsman in projections; column six gives the azimuth of the first to the second named station, counted from south round by west from  $0^\circ$  to  $360^\circ$ ; it is followed by the reversed azimuth in the next column. The distances are all referred to the surface of the spheroid at the average sea level. Those who may prefer the English foot as the unit of length can readily make the conversion from one unit into the other by means of the following tables:

1 m. =	3.28 087 ft.	1 ft. =	0.304 797 m.
2	6.56 174	2	0.609 595
3	9.84 261	3	0.914 392
4	13.12 348	4	1.219 189
5	16.40 435	5	1.523 986
6	19.68 522	6	1.828 784
7	22.96 609	7	2.133 581
8	26.24 695	8	2.438 378
9	29.52 782	9	2.743 175
10	32.80 869	10	3.047 973

or the logarithm factors may be used, viz.:  $\log 3.2808693 = 0.5159889$   
 and  $\log 0.30479727 = \bar{9}.4840111$

To convert metres into statute miles, we have:

1 m.	= 0.000 621 38 st. mls.
2	0.001 242 75
3	0.001 864 13
4	0.002 485 51
5	0.003 106 88
6	0.003 728 26
7	0.004 349 64
8	0.004 971 01
9	0.005 592 39
10	0.006 213 77

also  $\log 0.0006213767 = \bar{6}.7933550$

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,  
 April 16, 1886.

*Index of stations in Massachusetts.*

Names of stations.	Page.	Names of stations.	Page.
Abbott's Rock, stone beacon.	318	Assonet, spire.	380
Adams School, flagstaff.	336	Atlantic House, chimney.	346
Agamenticus (Me.).	304	Attleborough, Catholic church.	388
Agassiz Museum.	338	Atwood.	352
Alander Mountain (Borden).	390	Ayer's Hill (Borden).	310
Alden (Borden).	348	Back River Harbor.	372
Alex.	384	Bailey's wharf.	310
Almy.	372	Baker's Hill.	344
Alumpond (Borden).	386	Baker's Island light-house, 1834-1877.	316
Amesbury Mills, tall white spire.	308	Bald Hill (Ct.).	304
Amherst, Agricultural College, belfry.	404	Bald Hill (Borden).	388
Amherst, Agricultural College, drill hall, tower.	404	Bald Peak (or Mount Washington, or Mount Everett, or Taughanuc Mountain, or Dome Peak).	308
Amherst, Agricultural College, flagstaff.	404	Ballard.	322
Amherst City, Methodist church, tower.	404	Ball Peak (or Mount Riga) (Ct.).	392
Amherst, College Chapel.	394	Baptistville, First Baptist church, spire.	398
Amherst, College Hall.	404	Bare Top.	378
Amherst, Congregational church, spire.	404	Barn, cupola.	358
Amherst, Episcopal church, spire.	404	Barnstable.	356
Amherst, Lawrence Observatory.	404	Barnstable court-house (Borden), 1835.	356
Amherst, Walker Hall, tower.	404	Barnstable light-house, 1846.	356
Amherst, Williston Hall, tower.	404	Barnstable, Unitarian spire.	356
Andrews' Point.	312	Barnstable, west spire.	356
Angelica Point.	370	Barrel Beacon.	340
Annisquam Harbor light-house, 1834-1849.	314	Bartlett.	308
Annisquam, pole on rock.	314	Basin.	360
Apple Island, flag.	330	Bass Hole.	356
Assonet.	378	Bass River.	358
Assonet, flat-topped church, west gable, chimney.	380		



*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Bass River light-house, 1875.	358	Boston, Catholic cathedral, statue.	338
Batt's Hill.	308	Boston, Hanover street brick church.	338
Battery wharf.	328	Boston, Hollis street church.	338
Battlecock.	406	Boston jail, cupola.	338
Bay State Iron Works.	336	Boston light-house, 1834-1847.	338
Bay State Steam Engine Works.	336	Boston Neck, dark spire with clock.	338
Beacon.	380	Boston, Saint Mary's church, north spire.	338
Beacon Hill 1.	314	Boston, State House.	320
Beacon Hill 2.	314	Boston, State prison, cupola.	338
Beacon Hill, magnetic station, 1849.	314	Boulder west of Salem turnpike.	320
Beaconpole, Rhode Island.	304	Boundary Rock (Borden).	394
Beaconpole (Borden), Rhode Island.	386	Bourne's Hill.	352
Bear Mountain (Borden).	394	Bowditch's Ledge beacon.	318
Becket (Borden).	390	Bowman's Hill observatory.	368
Belchertown, Baptist church, tower.	400	Bowman's Point.	368
Belchertown, First Congregational church, tower.	400	Box Hill (Ct.).	304
Belchertown, High School, tower.	400	Boyden's (Col.) barn, cupola.	406
Belchertown, Methodist church, tower.	400	Boylston School, cupola.	336
Belle Isle.	328	Brace Mountain Monument (New York).	390
Berlin Mountain (Borden) (N. Y.).	390	Bradford.	382
Beveled Barn.	378	Brandybrow (Borden) (N. H.).	310
Beverly Point, flag in tree.	316	Brant.	348
Beverly powder-house.	316	Brant Point light-house (Borden), 1835.	366
Beverly Rocks.	316	Brant Point light-house, 1867-1875.	364
Beverly, tall spire with turrets.	316	Breakwater, east end, spindle.	362
Billingsgate light-house, 1835-1847.	354	Breed's Island.	330
Billingsgate light-house, 1868.	350	Brewster.	356
Birch.	382	Brewster, Unitarian church, spire.	356
Bird Island.	330	Brick factory.	332
Bird Island beacon.	330	Brick factory near Mystic River.	326
Bird Island light-house, 1835-1844.	376	Brick-yard.	382
Bishop and Clerks.	362	Briggs (Cape Cod Bay to Boston Bay).	350
Bishop and Clerks light-house, 1875.	362	Briggs (Taunton River).	382
Blackbeard.	378	Brighton, east church.	338
Blackfish Creek.	352	Brighton, west church with clock.	340
Black Rock.	344	Brookhouse's house.	320
Blind Asylum.	322	Brookline, Dr. Pierce's church.	340
Blue Hill.	304	Brown's Hill (Taunton River).	378
Blue Hill (Borden).	322	Brown's Hill (vicinity of Salem).	316
Bluff (Nantucket).	364	Brush.	394
Bluff (Taunton River).	376	Bryant's Hill.	386
Bluff Head, flag.	330	Bunker Hill, Catholic church.	330
Bolles.	316	Bunker Hill Monument.	330
Bonney.	350	Bunkin Island, flag.	344
<b>Boston Bay.</b>	320	Burns.	376
Boston, Berkley street, yellow spire.	338	Burnham Brown, flag.	314

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Burnham Essex, flag in tree.	314	Charles Neck.	374
Burnt Swamp (Borden).	388	Charles River tripod.	336
Burt.	380	Charlestown, brick church, cross.	338
Butler's Hill.	314	Chase.	376
<b>Buzzard's Bay.</b>	370	Chatham.	350
Byfield church, square tower.	312	Chatham, Congregational church, belfry, 1846.	360
Calvary.	376	Chatham, Congregational church, spire, 1868-1880.	360
Cambria.	352	Chatham flagstaff, 1868.	360
Cambridge, Baptist church.	328	Chatham north light-house, 1880.	360
Cambridge, gas works, chimney.	328	Chatham south light-house, 1846.	360
Cambridge, observatory, center of dome.	306	Chatham south light-house, 1880.	360
Cambridge, observatory, meridian mark.	322	Chatham spire.	360
Cambridge, observatory, west transit.	322	Chelsea Bridge.	326
Cambridge, Unitarian church.	328	Chelsea, brown tower.	326
Cambridgeport, flagstaff near engine-house.	328	Chelsea, church.	326
Cambridgeport, observatory dome.	328	Chelsea, dark spire, cross.	326
Cambridgeport, redoubt, flagstaff.	328	Chelsea, tall dark spire.	326
Cambridgeport, Universalist church.	328	Chelsea, white spire, martin-hole windows.	326
Camp.	358	Chelsea, white spire, three tiers windows.	326
Canonicus.	386	Chelsea, white spire with clock.	326
Cape Ann north light-house, 1834-1849.	316	Chestnut Hill.	404
Cape Ann north light-house, 1878.	316	Chicopee, Catholic church, spire.	396
Cape Ann south light-house, 1834-1849.	316	Chicopee, French Catholic church, spire.	396
Cape Ann south light-house, 1878.	316	Chicopee, skating rink, spire.	398
<b>Cape Cod Bay and Peninsula.</b>	350	Chicopee, town hall, spire.	396
<b>Cape Cod Bay to Boston Bay.</b>	346	Chicopee Falls, Catholic church, spire.	398
Cape Cod (or Highlands of Truro) light-house, 1835-1847.	354	Chicopee Falls, Congregational spire.	398
Cape Cod (or Highlands of Truro) light-house, 1877.	350	Chicopee Falls, Methodist spire.	398
Cape Poge.	366	Chicopee Falls, New Baptist spire.	398
Cape Poge light-house (Borden), 1835.	370	Choate.	314
Cape Poge light-house, 1845-1875.	306	Church spire summer-house.	320
Carolina Hill.	346	City.	376
Carpenter.	382	Clark.	382
Carpet-cleaning factory.	336	Clarksburg (Borden).	390
Car-shed, northeast ventilator.	334	Clark's Cove.	362
Castle Hill (Borden).	322	Clark's Mountain, flag in tree.	316
Castle Island.	324	Clark's Point.	372
Cat Hill.	322	Clark's Point light-house, 1835-1844.	374
Cat Island, east rock.	320	Cloverden.	336
Cat Island, flagstaff, 1848.	320	Cloven-den Observatory (zenith telescope).	336
Center.	332	Coal-shed flagstaff.	332
Centerville church.	362	<b>Coast north of Cape Ann.</b>	308
Central wharf, cupola.	336	Coatue Point.	364
Chandler's Hill (Borden).	390	Coatue Point 2, 1875.	364
		Coddon.	316

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Cohasset church.	346	Derby's wharf light-house, 1877.	320
Coleman.	350	Desert Hill.	366
Collier's Ledge.	362	Dexter's Point.	318
Colonel's Mountain (Borden).	392	Dickinson.	394
Commercial Point, wharf, flag.	342	Dickinson's (Chas. R.), barn, cupola.	404
Coney Island, flag.	318	Dodge's Hotel, cupola.	318
Connecticut line (Borden).	390	Dodge's stable, turret.	380
Connecticut line signal (Borden).	394	Dogtown, Methodist church.	314
Connecticut River Lumber Company's chimney.	402	Dome Peak (or Bald Peak, or Mount Everett, or	
<b>Connecticut River Valley.</b>	392	Mount Washington, or Taughanuc Mountain).	308
Conway township, southeast corner.	404	Dorchester, church with clock.	342
Copecut.	304	Dorchester, Dr. Codman's church.	342
Cord.	384	Dorchester Heights.	320
Corey.	306	Draw, northwest corner, iron crane.	334
Corner Stone (New York).	392	Dread Ledge Beacon.	322
Cotuit Neck.	370	Dug Hill (Borden).	392
Cove.	360	Dummer Academy.	312
Crafts.	394	Dumpling.	394
Crane Neck.	308	Dumpling Rock (Round Hill) light-house, 1835-	
Cromeset Neck.	372	1844.	374
Crossing, signal pole.	332	Durfee's cupola.	380
Crow's Lookout.	360	Duxbury astronomical longitude station, 1869-	
Crow Point.	344	1870.	348
Crusoe House, flagstaff.	324	Duxbury Pier light-house, 1877.	348
Cumming's (D.), flagstaff.	360	Eagle Island, flag.	318
Cunard Wharf, pole, 1860.	334	East Bench Mark.	398
Cunard Wharf, flagstaff, 1847.	334	East Boston.	324
Cunard Wharf, flagstaff, 1877.	334	East Boston, brick church, dark spire.	324
Cupola.	382	East Boston, dry-dock, post.	324
Cushing's (J. P.) house.	330	East Boston Elevator.	324
Cushman's house, cupola.	326	East Boston, granite church, dark spire.	324
Cuttyhunk.	306	East Boston Iron Works, chimney.	324
Cuttyhunk light-house, 1835-1844.	376	East Boston Point, flag.	324
Danvers Insane Asylum.	318	East Boston Reservoir.	324
Danvers New Mills, tall spire.	318	East Boston Reservoir 2, 1877.	324
Danvers Plain, tall spire.	318	East Boston, shipyard, east wharf, post.	324
Dartmouth.	370	East Cambridge, church near court-house.	328
Davis Hill.	366	East Cambridge court-house, cupola.	328
Davis Neck.	368	East Chop.	368
Deacon Elihu's barn, tower.	404	East Chop light-house, 1875.	368
Dean.	382	East Chop 2, 1875.	366
Deer Island.	320	East Chop Telegraph.	368
Deer Island Beacon.	334	East Duxbury, belfry.	348
Deer Island, flag, 1860.	334	Eastern Avenue, wharf, post.	334
Deer Island, Hospital, cupola.	334	Eastern Point light-house, 1834-1849.	316
Depot.	378	Eastham.	356

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Eastham, Congregational spire.	354	Feeding Hills, Congregational spire.	396
Easthampton, First Congregational church, spire.	400	Feeding Hills, Methodist spire.	396
Easthampton, Methodist church, tower.	400	Ferry wharf, chimney.	380
Easthampton, Payson Congregational spire.	400	Fish-house, north gable.	358
Easthampton, Town Hall, tower.	400	Fish Rock.	396
Easthampton, Williston, Knight & Co.'s chimney.	400	Fitchburg Depot.	330
Easthampton, Williston Mills, tower.	400	Fitchburg Round House.	332
Easthampton, Williston Seminary, Gymnasium tower.	400	Flag-staff, corner of Dorchester street and turn-pike.	342
East Longmeadow, Congregational spire.	396	Florence.	378
East Plymouth.	362	Florence, Catholic church spire.	402
East Rock (R. I.).	308	Florence, Congregational church spire.	402
East Scargo (Borden).	356	Florence, Cosmian Hall, clock tower.	402
East Tidal Bench Mark.	398	Florence, engine-house, tower.	402
East Weymouth church.	346	Florence Manufacturing Co.'s Mill, tower.	404
Eaton's Hill, flag.	344	Florence, Methodist church, spire.	402
Eddy.	384	Florence, school-house, tower.	402
Edgartown.	366	Folger.	364
Edgartown light-house, 1875.	366	Folger (astronomical latitude station, 1866).	364
Edgartown spire.	366	Folly Hill.	316
Edgeworth Mills, round chimney.	326	Forbes.	344
Edward.	384	Forked Pond.	364
Eel River, steeple.	348	Fort Hill wharf, post.	336
Egg Rock.	322	Fort Independence, flagstaff, 1861.	340
Egg Rock light-house, 1877.	322	Fort Lee.	316
Eldridge (Buzzard's Bay).	372	Fort Pickering light-house, 1877.	318
Eldridge (Cape Cod).	358	Fort Warren, west gable of house.	342
Elisha.	384	Foster's wharf, post.	334
Elm.	384	Foxborough Baptist church, white spire.	388
Essex powder-house.	314	Foxborough Orthodox church, dark spire.	388
Essex, red-top church.	314	Frederick.	382
Facing Rock.	394	French.	382
Fair Haven, black spire.	374	French's Hill.	308
Fall River.	378	Fulton Wire Works, south chimney.	340
Fall River 2, 1861.	378	Further Creek.	364
Fall River derrick.	380	Gallop Island, flag.	340
Fall River spire, 1861.	380	Gallop Island 2, 1860.	340
Fall River tower, 1861.	380	Gambrel roof, northeast gable.	334
Falmouth.	370	Gardner's Neck.	376
Falmouth, spire.	374	Gas Works, near Malden Bridge.	336
Faneuil Hall.	330	Gas Works, north end of Boston.	336
Farm-house, white chimney.	380	Gas Works, ventilator.	340
Farm school-house, southeast gable.	342	Gay Head.	366
Fawn Beacon.	334	Gay Head light-house, 1835 (Borden).	366
Fay's Mount (Borden).	388	Gay Head light-house, 1843-1845.	366
Feeding Hills.	394	Gay Head light-house, 1875.	368

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
George.	386	Haines, N. Y.	390
George's Island.	340	Halfway Rock, beacon.	320
German Hill.	352	Hall.	382
German Hill (Borden).	356	Hamblin's Hill.	352
Gibbs Pond.	364	Hamblin's Mound.	352
Glass Works, east gable.	332	Hampden.	386
Globe village, chimney.	378	Hampton (N. H.).	308
Gloucester, east church.	316	Hampton Falls (N. H.).	306
Gloucester, Universalist church.	316	Hangman's Ledge Beacon.	344
Gooseberry Neck.	370	Harding's Beach (or Stage Harbor) light-house,	
Gould's Transitory, 1865.	338	1880.	360
Governor's Island.	320	Hardy's Rock, beacon.	318
Governor's Island 2, 1860.	324	Harwich belfry, 1835-1846.	358
Governor's Island 3, 1877.	324	Harwich Port.	358
Grain-mill, west chimney.	326	Hasnebumskit (Borden).	388
Granby Congregational spire.	400	Hatch (Cape Cod Bay to Boston Bay).	350
Grand Junction, wharf.	336	Hatch (Taunton River).	382
Grape Island, flag.	344	Hatchet (Borden).	388
Grave.	384	Hatfield, Congregational church, spire.	404
Graves.	328	Hatfield, Smith Academy, tower.	404
Graveyard.	378	Hatfield, North Base (1832).	392
Gray's wharf, long brick building.	334	Hatfield, South Base (1832).	392
Great Aquavitæ, stone beacon.	318	Hawe's Hill (Borden).	390
Great Boar's Head (N. H.).	308	Hayden's Hotel.	322
Great Brewster.	328	Haydensville, Catholic church, spire.	404
Great Brewster 2, 1860.	328	Haydensville, Congregational church, spire.	404
Great Haste.	318	Helderberg (N. Y.).	304
Great Hill.	370	Henry.	384
Great Meadow.	304	Herbert.	382
Great Misery, flag.	318	Herring Pond.	366
Great Point (Nantucket) light-house, 1835-1875.	306	Herring River, spire.	358
Great Quincy.	322	High.	378
Great Rock.	386	Highland.	352
Great Rock, spindle.	362	Highland House, north tower.	368
Green Island, flag.	330	Highlands of Truro (Cape Cod) light-house, 1847.	354
Green Island 2, 1860.	330	Highlands of Truro (Cape Cod) light-house, 1877.	350
Greylock (or Saddle Mountain).	304	High Ridge.	392
Griffin's Island.	350	High school, cupola.	364
Grover's Cliff.	322	Hilliard's Knob.	392
Guide Post, west end of mill-dam.	328	Hingham, church with clock.	344
Gumpus (Borden) (N. H.).	312	Hingham, Great Plain church.	346
Gurnet.	348	Hingham, old church.	344
Gurnet (Plymouth) light-house (Borden), 1835.	348	Hingham, old Colony house, cupola.	346
Gurnet (Plymouth) light-house, 1848-1870.	348	Hitchcock (Borden).	392
Hadley, First Congregational church, spire.	402	Hog Island Harbor.	372
Hadley, Second Congregational church, spire.	402	Hog Island 3 (R. I.).	376

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Hog Island tripod.	336	Jackson's Hill (Borden).	390
Holland's (H.) house, chimney.	396	James and Pope's timber dock.	340
Holmes.	352	Jenksville church tower (1).	400
Holmes' factory.	332	Jenksville church tower (2).	400
Holmes' Hole (or West Chop) light-house, 1835-1845.	370	Jesse.	386
Holmes' Hole (or West Chop) light-house, 1875.	370	Jilson (Borden).	392
Holmes' Hole, spire.	370	Joe Sandford (Borden).	376
Holmes' Hole, windmill (Borden).	370	Joe's Rock (Borden).	386
Holt.	306	Johnson.	382
Holyoke, city hall, tower.	398	Kettle Island.	316
Holyoke, engine-house, tower.	398	Kimball.	384
Holyoke, French Catholic spire.	398	Kimball's house, center chimney.	340
Holyoke, First Congregational belfry.	398	King.	384
Holyoke, Second Baptist tower.	398	King Oak Hill, pole.	346
Holyoke, Second Congregational tower.	398	King's Rock (Borden).	386
Holyoke, Saint Jerome's Catholic spire.	398	Kingston.	348
Holyoke, Windsor Hotel tower.	398	Kingston spire.	348
Hopkins.	360	Kotayma House, north tower.	368
Hoppin Hill.	388	Lane's Cove, white spire.	312
Hospital Point light-house, 1877.	318	Large chimney, with rail.	380
Hull, Oregon House, cupola.	344	Lawrence School, cupola.	340
Hull, Steamboat Hotel, cupola.	344	Legg's Hill.	318
Hunt.	382	Leverett Congregational church spire.	406
Hyannis.	306	Lewis.	350
Hyannis light-house, 1875.	362	Lewis' wharf, cupola.	330
Hyannis, Universalist spire.	362	Leyden and Guilford (Borden).	394
Hyannis, west spire.	362	Lincoln's wharf, post.	334
Indian.	306	Little Aquavitæ, pole.	318
Indian Brook.	352	Little Compton 2 (Rhode Island).	386
Indian Hill.	362	Little Haste Beacon.	318
Indian Hill flagstaff, 1878.	310	Little Nahant.	322
Indian Neck.	372	Little Old Town.	312
Indian Orchard, church spire.	400	Lombard Head.	352
Indian Orchard, Congregational tower.	400	Londoner Beacon, 1849.	314
Indian Orchard, French Catholic spire.	400	Lone fir tree.	388
India wharf, cupola.	336	Long Island Head light-house, 1846-1860.	320
India wharf, post.	336	Long Island Hotel, cupola.	342
Ipswich Beacon, 1849.	314	Long Island, south end, flag.	342
Ipswich light-house, 1849.	314	Long Island, south end 2, 1860.	342
Ipswich, tall dark spire.	314	Longmeadow, Congregational spire.	396
Ipswich, Town Farm.	312	Long Neck.	372
Iron Bolt.	392	Long Point light-house, 1847.	354
Iron smoke-stack.	332	Long Point light-house, 1877.	350
Isles of Shoals (N. H.).	306	Long Point school-house.	354
Ivy (Ct.).	304	Long wharf.	324
		Long wharf 2, post, 1860.	324

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Long wharf building.	334	Mattapoissett, gray spire.	374
Loring's machine shop, wharf.	334	Mattapoissett Neck.	374
Lovel's Island, pole.	340	Mayo.	360
Lowell church (Borden).	312	Mayo's Beach light-house, 1877.	354
Lowell Depot, flagstaff.	330	Mayo's house, south chimney.	360
Lowell Draw, flagstaff.	330	Meadow.	380
Lowell Round House.	330	Medford, tall square chimney near Malden Bridge.	326
Ludlow, Congregational spire.	400	Medford, Unitarian church.	326
Ludlow, Methodist tower.	400	Menauhant Hotel, west chimney.	368
Lutkin's Hill.	314	Menauhant Landing, flagstaff.	368
Lynn, East church, green tower.	322	Mendal (Borden).	370
Lynn, high rock.	322	Milk Island, flag.	316
Lynn, West church, turret.	322	Milldam, regatta house, flagstaff.	336
Machine shop, tall chimney on ridge-pole.	340	Milldam, yellow house, chimney.	336
McCarthy.	394	Miller's River, head of, church.	336
Mack.	378	Mill Hill.	350
McLean's Asylum, north dome.	330	Mill with conical cupola, chimney.	380
McSparran (R. I.).	308	Milton Mills, tall church spire.	346
Malden Bridge.	326	Milton, old church.	346
Malden Bridge, yellow house.	326	Minot's Ledge light-house, 1847-1877.	346
Malden church, tall spire.	326	Mishaum Point.	370
Malden, yellow spire.	326	Mitchell's house (astronomical station, 1845-1849).	364
Manchester church, dark spire.	318	Molasha Hill.	366
Mannersen.	358	Monadnock (N. H.).	304
Manning's Hill.	312	Monaunt Hill.	368
Manomet.	304	Monk's Hill.	346
Mansfield, old Unitarian church.	386	Monomoy.	352
Maplewood.	384	Monomoy light-house, 1835-1846.	356
Marblehead, black top church.	320	Monomoy light-house, 1867-1880.	356
Marblehead light-house, 1848-1877.	320	Monument church.	374
Marblehead Neck, flag.	320	Moon Head 1.	340
Marblehead Rock, beacon.	320	Moon Head 2, 1860.	340
Marine Hospital, flagstaff.	332	More's Hill (Borden).	392
Marsh (Cape Cod).	358	Morrill.	310
Marsh (Taunton River).	378	Morris Island.	358
Marsh and Jones (Borden).	312	Morris Island 2, 1880.	360
Marston's Mill.	362	Mosquito.	360
<b>Martha's Vineyard and Vineyard Sound.</b>	366	Mound (R. I.).	376
Martin.	384	Mount Auburn.	328
Marvin's cottage, cupola.	362	Mount Daniel (Borden).	386
Mason.	382	Mount Equinox (Vt.).	304
<b>Massachusetts, New York, and Connecticut Boundary.</b>	390	Mount Esther.	392
<b>Massachusetts and Rhode Island Boundary.</b>	386	Mount Grace (Borden).	392
Massachusetts North Base.	304	Mount Holyoke Hotel, flagstaff.	402
Massachusetts South Base.	304	Mount Hope (R. I.).	308
Mattapoissett.	378	Mount Hope 2 (R. I.).	376
		Mount Lincoln.	392
		Mount Rafinesque (N. Y.).	304

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Mount Riga (or Ball Peak), (Connecticut).	392	New Bedford Beacon.	374
Mount Schaum.	352	New Bedford court-house (Borden).	370
Mount Toby.	406	New Bedford Fort.	372
Mount Tom.	304	New Braintree, Congregational spire.	402
Mount Tom (Borden).	394	Newbury, Belleville church.	310
Mount Warner.	394	Newbury, Upper Green church.	310
Mount Washington (or Mount Everett, or Bald Peak, or Dome Peak, or Taughanuc Mount).	308	Newburyport Academy.	310
Mouth of Merrimac, chimney of house.	310	Newburyport, beacon on north pier.	310
Mugget (Borden).	388	Newburyport, east light-house, 1850-1851.	310
Muskeget Island.	364	Newburyport, Federal street church.	310
Nahant.	320	Newburyport, Harris street church.	310
Nahant 2, 1860.	324	Newburyport light-house (Borden), 1834.	310
Nahant (Borden).	322	Newburyport light-house, 1878.	310
Nahant Hotel, cupola.	326	Newburyport, Pleasant street Unitarian church.	310
Namequoit.	360	Newburyport west light-house, 1850-51.	310
Nantasket.	306	New England Glass Company, chimney.	332
<b>Nantucket and vicinity.</b>	362	New Falmouth.	374
Nantucket Baptist church.	364	Nichols.	378
Nantucket (Borden).	366	Nix's Mate.	340
Nantucket Cliff.	306	Nobska Point light-house, 1835-1875.	368
Nantucket Cliff Range Beacon, front, 1875.	366	No Man's Land.	368
Nantucket Cliff Range Beacon, rear, 1875.	366	Monotuck Hotel, tower.	402
Nantucket (Great Point) light-house, 1835-1875.	306	Nootas.	308
Nantucket, north towered church.	364	Nootas (Borden).	372
Nantucket Range Beacon, 1875.	364	North Amherst, Congregational church spire.	404
Nantucket, south towered Unitarian church.	364	Northampton, Catholic church, tower.	402
Nashaquitsa Cliff.	366	Northampton, Episcopal church, spire.	402
Nashawena.	372	Northampton, First Congregational church spire.	402
National dock building.	334	Northampton, Lunatic Asylum, tower.	402
Nauset Beach.	356	Northampton, Methodist church spire.	402
Nauset Center light-house, 1846.	354	Northampton, Round Hill, flagstaff, 1885.	402
Nauset Harbor.	354	Northampton, Second Congregational spire.	402
Naushon.	370	North Brighton, dark spire.	340
Naushon (Borden).	376	North Dennis.	356
Naushon northeast.	372	North Dennis 2, 1868.	356
Naushon southwest.	372	North Dennis, gray spire.	356
Naval Hospital.	326	North Dennis, white spire.	356
Navy Yard, battery.	328	North Dighton.	380
Navy Yard, chimney.	330	Northeast corner of Connecticut (Borden).	388
Nealy's house.	332	North Falmouth, spire.	374
Ned's Point light-house, 1844.	374	North Gooseberry Island, flag.	318
Neponset church.	344	North Hadley, Congregational church spire.	404
Neptune House, flagstaff.	326	North Marshfield, Unitarian church spire.	350
New.	378	North Pettick Island.	342
New Bedford Baptist church.	374	North Pettick Island 2, 1860.	344
		North Plymouth Rope Works.	348



*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
North Pond.	364	Penikese (Borden).	374
North Warner.	394	Pepperell (Borden).	390
North Wellfleet, Congregational belfry.	354	Perry's Peak.	304
North Wellfleet, Methodist belfry.	354	Pigeon Hill.	386
Northwest corner of Massachusetts (Borden).	390	Pig Rock Beacon.	346
Northwest corner of Rhode Island (Borden).	388	Pine (Cape Cod).	360
North Weymouth church.	346	Pine (Taunton River).	384
Norton, dark red spire.	388	Pine Hill (Buzzard's Bay).	370
Oak Hill.	386	Pine Hill (Rhode Island).	376
Observatory with red roof, flagstaff.	368	Pine Tree Boundary, stone monument (Borden).	312
Ocean House, cupola.	320	Pittsfield, First Congregational church.	392
Octagonal building.	332	Planing mill, chimney.	336
Old Harbor.	358	Pleasant Bay.	356
Old Town.	308	Plum Island 1.	312
Old Town, church spire.	310	Plum Island 2.	312
One-story red building.	334	Plum Island, magnetic station.	310
Organ factory.	330	Plymouth.	348
Orleans.	356	Plymouth Cliff.	362
Orleans 2, 1868.	352	Plymouth court-house (Borden), 1835.	348
Orleans Orthodox spire.	356	Plymouth (Gurnet) light-house (Borden), 1835.	348
Orne.	306	Plymouth (Gurnet) light-house, 1848-1870.	348
Osterville.	362	Plymouth, national monument.	348
Osterville Point.	362	Plymouth pier head.	348
Osterville spire.	362	Pocasset (Rhode Island).	306
Otter street.	332	Pocasset spire.	374
Outer Brewster.	338	Pochet.	358
Outer Brewster 2, 1860.	338	Point Allerton beacon, 1860.	342
Ox Pasture Hill.	312	Point Allerton, flag.	342
Packard.	392	Point Curve.	332
Padanaram.	374	Point Gammon.	352
Padanaram, gray spire.	374	Point Gammon 2, 1875.	358
Padelford.	384	Point Gammon light-house, 1835-1847.	356
Paine's Hill observatory.	344	Point Shirley, foundry chimney.	328
Palmer's Island light-house, 1875.	376	Poole's Hill.	312
Palmer, Universalist church spire.	400	Poplar Hill (Borden).	312
Pamanset River.	374	Poplar Hill, stone monument (Borden).	312
Pamet.	352	Powderhorn.	306
Paradise Rock (Rhode Island).	386	Powderhorn 2, 1877.	320
Parker's Hill.	344	Powder Point.	348
Pasque.	372	Powers & Melville's elevator.	332
Patuccawa (New Hampshire).	306	Powow.	306
Peaked Cliff.	352	Powow (Borden).	308
Peaked Mount.	392	Prentice's coal-wharf, post.	334
Peck's chimney.	332	<b>Primaries..</b>	304
Pelham, church spire.	404	Prince street, draw-tender's house.	334
Penikese.	372	Proctor's barn.	312

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Prospect (New York).	304	Rock Rimmon.	394
Prospect Chilmark.	366	Round brick building, iron rod.	332
Prospect Hill (Connecticut).	390	Round building, ventilator.	332
Prospect Hingham.	346	Round Hill.	372
Prospect House, cupola flagstaff.	368	Round Hill (Dumpling Rock) light-house.	374
Prospect Rowley.	306	Rowley, church spire with turrets.	312
Prospect Somerville.	330	Rowley Marsh.	312
Prospect Waltham.	306	Roxbury, Dr. Putnam's church.	342
Proven's Mount.	392	Roxbury, Jamaica Plains, tall church spire.	340
Provincetown.	350	Roxbury, laboratory chimney.	342
Provincetown Academy.	354	Roxbury, new Unitarian church.	342
Provincetown, Baptist church belfry.	354	Roxbury Oil Works, chimney.	342
Provincetown, Methodist center church.	354	Ryant Bush.	392
Provincetown, Methodist centenary church.	354	Saddle Mount (Borden).	390
Provincetown, Methodist church, belfry.	354	Saddle Mount (or Greylock).	304
Provincetown, new Universalist church, spire.	354	Sagamore Head.	344
Provincetown, old Universalist church, belfry, 1835-1847.	354	Sailor's Home, cupola.	334
Provincetown, Orthodox spire.	354	Salem, Howard street church.	318
Provincetown school-house.	354	Salem, South church, corner of Cambridge and Chestnut streets.	318
Quaker (Rhode Island).	306	Salisbury Beach.	308
Quicksand.	372	Salisbury church.	308
Quicksand 2, 1870.	388	Salisbury Marsh.	308
Quicksand (Borden).	376	Salisbury Marsh (Borden).	308
Quincy, Bent's Point church.	346	Salt Island, flag.	316
Quincy, black top church.	346	Salvage.	314
Quincy, stone church.	346	Sampson (Borden).	368
Race.	352	Sampson (Cape Cod).	358
Race Point light-house, 1835-1847.	354	Sampson (Martha's Vineyard).	306
Race Point light-house, 1877.	350	Sandford (Connecticut).	304
Railcut.	312	Sandwich, Orthodox spire.	362
Railroad tripod.	340	Sankaty Head.	364
Rainsford Island, flagstaff, 1846.	344	Sankaty Head light-house, 1867.	364
Rainsford Island, flag, 1860.	344	Sargent's observatory.	340
Rattle, flag in tree.	394	Sassacus.	386
Rattlesnake (Borden).	394	Scargo.	350
Red Brush.	386	School-house.	382
Richmond Hill.	378	School-house Hill.	378
Ridge.	376	Scituate.	322
River.	380	Scituate light-house, 1834-1849.	348
Riverside Press, chimney.	336	Scituate Unitarian church.	350
Roach.	384	Sconticut Neck.	372
Rockheap.	384	Scorton Hill.	352
Rockland House, cupola.	346	Scorton Neck.	352
Rock Point.	352	Scraggy Neck.	374
Rockport, red top church.	314	Seabrook (New Hampshire).	308

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Sears.	360	South Hadley, Congregational church spire.	398
Seaview House, north tower.	368	South Hadley, Female Seminary, observatory.	398
<b>Secondaries.</b>	306	South Hadley Falls, Catholic church spire.	398
Secondary signal (Borden).	394	South Hadley Falls, Congregational church spire.	398
Seymore's Hill (Borden).	390	South Hadley Falls, Methodist church spire.	398
Shawaukemo.	364	South Pettick Island.	344
Shed, upper gable.	332	South Pocasset spire.	374
Shells.	360	South Wellfleet, Congregational church belfry.	354
Shingle Hill.	394	South Wellfleet, Methodist meeting-house.	354
Shootflying.	306	Southwest corner of Massachusetts (Borden).	390
Shutesbury, Baptist church.	406	Spectacle Island, flag.	342
Shutesbury, Congregational church spire.	406	Spencer (Rhode Island).	306
Shutesbury, house, chimney.	406	Sprague.	346
Simmons 2, 1870 (Rhode Island).	386	Springfield Arsenal, clock tower.	396
Sippican church.	374	Springfield, court-house, tower.	396
Sippican Neck.	372	Springfield, First Baptist church spire.	396
Sipson's Island.	360	Springfield, Florence street Methodist church spire.	396
Slade.	378	Springfield, Hope Congregational church tower.	396
Small red house on marsh, chimney.	336	Springfield, North Congregational church spire.	396
Small's Hill (Borden).	352	Springfield, Saint Joseph's Catholic church spire.	396
Smith's (Edwin) barn, cupola.	402	Springfield, Saint Michael's church spire.	396
Somerset.	378	Springfield, South Congregational church tower.	396
Somerset 2, 1874.	376	Springfield, State-street Methodist church.	396
Somerset meeting-house.	380	Springfield, water shops, tower.	396
Somerset spire.	380	Spring Hill Academy.	362
Somerset spire, 1861-1874.	380	Spruce Hill (Borden).	390
Somerville, church near Malden Bridge.	328	Squam Head.	364
Somerville, church on hill.	328	Squantum.	342
Somerville, red church.	328	Squawbetty.	384
South Amherst, church spire.	402	Squawbetty, nail factory.	386
South Amherst, Monson's barn, cupola.	402	Squawbetty, white spire.	386
South Bay, tripod.	334	Stage Harbor (or Harding's Beach) light-house, 1880.	360
South Boston, dark-spire cross.	338	Standard sugar refinery.	332
South Boston Flats, A.	338	Standish.	348
South Boston Flats, B.	338	Standish monument.	348
South Boston Flats, C.	338	State street block.	330
South Boston Flats, D.	338	Station south of Nauset lights.	356
South Boston Flats, E.	338	Steep Brook.	376
South Boston Point.	324	Steep Brook church.	380
South Boston Reservoir.	338	Stone powder-house.	326
South Boston Sea-wall.	332	Stonewall.	384
South Danvers, tall spire.	318	Stout.	352
South Deerfield, Congregational church spire.	406	Straitsmouth light-house, 1849.	314
South Dennis.	358	Straitsmouth light-house, 1851.	314
South Dennis, north spire.	358		
South Dennis, south spire.	358		

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Strawberry Hill, barn.	344	Tuckanuck Telegraph.	362
Strong.	360	Tudor cupola.	334
Studley.	350	Tuft's College.	324
Succonneset.	370	Tuft's Hill (Borden).	390
Succonneset (Borden).	370	Turkey Hill.	344
Suffolk cordage factory, ball.	342	Two-story house, smoke-pipe.	332
Sugarloaf Hotel, north chimney.	406	Twopenny Loaf, flag.	314
Sugarloaf Hotel, south chimney.	406	Union Chapel.	368
Summer-house on high rock.	320	Unkonoonuc (New Hampshire).	304
Summer-house on hill.	342	Upper Harbor, inner beacon.	310
Sunderland, Congregational church spire.	406	Upper Harbor, outer beacon.	310
Sunderland school-house, tower.	406	Varnish factory, chimney.	336
Sursuit Creek.	358	Verification north base.	388
Swampscott church.	322	Verification south base.	388
Swanzy belfry, 1843-1861.	380	<b>Vicinity of Cape Ann.</b>	312
Swift's Hill.	370	<b>Vicinity of Salem.</b>	316
Sycamore.	384	Wachusett.	304
Tall chimney, north side of Mystic River.	326	Waite 1.	322
Tarpaulin Cove light-house, 1835-1845.	368	Waite 2.	322
Taughanuc Mount (or Mount Washington, or Mount Everett, or Bald Peak, or Dome Peak).	308	Walker.	384
Taunton Iron Works, chimney.	382	Walnut Hill (Borden).	394
<b>Taunton River.</b>	376	Wareham, Baptist church.	374
Taunton Unitarian church.	382	Ware's Hill, flagstaff, 1848.	320
Telegraph.	378	Warwick (Borden).	394
Telegraph Hill (Borden).	348	Washburn.	384
Tempes Knob.	372	Washington spire.	390
Ten Hill farm, flag.	324	Watcha Pond.	366
Ten Hill farm 2, 1860.	324	Watatick (Borden).	388
Ten Pound Island light-house, 1849.	316	Watatick State-line (Borden).	390
Terry.	378	Water tower.	388
Thatcher's Island.	314	Watertown, United States Arsenal.	330
Thayer's Hill, yellow house, chimney.	344	Water works.	384
Third Cliff.	350	Waverly House.	330
Thompson.	304	Webster's flagstaff.	350
Thompson's Hotel.	310	Webster's (Hon. D.) house, west chimney.	350
Thompson's Island, flag.	342	Weeks' barn, center chimney.	340
Thompson's Island 2, 1860.	342	Weeks' house, chimney.	340
Thompson's Island, pole near farm school.	342	Weetamoe.	386
Thrasher.	382	Weeweeder Pond.	364
Three Rivers, French Catholic church spire.	400	Wellington Hill, flag.	346
Tilton.	308	Wenaumet Neck.	372
Tinker's Island, pole on house.	320	West Bench-mark.	398
Truro Congregational church spire.	354	West Boston Bridge, pole on draw.	338
Tuckanuck Island, north house (Borden).	366	West Cambridge, tall spire with clock.	328
		West Chatham.	358

*Index of stations in Massachusetts.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
West Chop.	370	Wigwam.	394
West Chop 2, 1875.	366	Wilbraham, Congregational church spire.	400
West Chop (Holmes' Hole) light-house, 1835-1845.	370	Wilbraham, Rich Hall, tower.	398
West Chop (Holmes' Hole) light-house, 1875.	370	Wilbur.	382
West Duxbury, Unitarian church steeple.	348	Wild Harbor.	372
West Hampton, Congregational church spire.	402	Williams.	382
West Island.	370	Williamstown Congregational church (Borden).	390
West Island 2.	374	Wilson's (Foster) house, tower.	400
West Salisbury, church.	310	Winchell's Mount (Borden).	392
West Salisbury, powder-house.	308	Windmill Range.	364
West Springfield, First Congregational church spire.	396	Wing (Rhode Island).	386
West Springfield, Park street Congregational church spire.	396	Wing's Neck light-house, 1875.	376
West Yarmouth, spire.	358	Winnisimmet, church with clock.	328
Weymouth Great Hill.	346	Winslow's factory, corner.	332
Whately, Congregational church spire.	404	Winthrop Head.	324
White.	348	Winthrop Head 2, 1877.	324
White barn with square window, cupola.	380	Wood.	376
White church spire.	380	Wood End light-house, 1877.	350
White, flag in tree.	396	Woods.	384
White house, chimney.	368	Wood's Holl.	370
White house, south gable.	368	Wood's Holl, Episcopal church.	368
White's Hill.	322	Wood's Hotel.	312
Whitmore.	382	Woodward's Hill, flag.	316
		<b>Worcester and Middlesex Counties.</b>	388
		Yarmouth Port spire.	358
		Yellow Pine (New York).	304

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**TABLE OF GEOGRAPHICAL POSITIONS**  
**DETERMINED IN THE**  
**STATE OF MASSACHUSETTS**  
**AND**  
**CONNECTIONS WITH STATIONS IN SURROUNDING STATES.**  

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**TRIANGULATIONS OF 1832-1885.**

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## PRIMARY STATIONS.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Agamenticus, Me., astronomical azimuth and latitude station, 1847.	° / '' 43 13 24.630	760.1	° / '' 70 41 32.907	742.6
Thompson, astronomical azimuth and latitude station, 1846.	42 36 41.924	1293.6	70 43 49.164	1120.4
Unkoonuc, N. H., astronomical azimuth and latitude station, 1848.	42 58 59.864	1847.4	71 35 19.380	439.0
Blue Hill, astronomical azimuth station, 1845.	42 12 43.941	1355.7	71 06 52.638	1207.3
Wachusett, astronomical azimuth and latitude station, 1860 (C. & G. S. & B.).	42 29 20.784	641.4	71 53 13.984	319.4
Monadnock, N. H.	42 51 41.174	1270.6	72 06 30.776	698.6
Mount Tom, astronomical azimuth and latitude station, 1862.	42 14 30.798	950.2	72 38 55.056	1262.1
Bald Hill (Tolland County), Conn.	41 58 25.890	798.9	72 11 55.027	1266.9
Box Hill, Conn.	41 47 59.794	1844.9	72 27 21.404	494.1
Sandford, Conn., astronomical azimuth and latitude station, 1862.	41 27 42.801	1320.4	72 56 59.304	1376.0
Ivy, Conn.	41 52 18.500	570.7	73 13 27.926	644.0
Beaconpole, R. I., astronomical azimuth station, 1844.	41 59 42.468	1310.2	71 27 01.257	28.9
Great Meadow (C. & G. S. & B.).	41 52 45.138	1392.7	71 13 02.292	52.9
Copecut, astronomical azimuth station, 1844 (C. & G. S. & B.).	41 43 17.245	532.1	71 03 36.644	847.1
Massachusetts North Base, 1844.	42 03 06.592	203.4	71 12 24.871	572.0
Massachusetts South Base, 1844.	41 54 49.921	1540.3	71 18 16.114	371.3
Manomet, astronomical latitude station, 1867 (C. & G. S. & B.).	41 55 38.699	1194.0	70 35 28.128	648.1
Greylock or Saddle Mountain.	42 38 14.088	434.6	73 09 59.130	1347.2
Mount Equinox, Vt.	43 09 57.980	1789.2	73 07 02.708	61.2
Mount Rafinesque, N. Y.	42 47 21.155	652.9	73 36 58.818	1336.8
Perry's Peak (C. & G. S. & B.).	42 25 15.648	482.8	73 22 48.781	1115.3
Yellow Pine, N. Y.	42 29 28.727	886.4	73 40 27.902	637.3
Helderberg, N. Y.	42 37 39.072	1205.7	74 00 38.487	877.0
Prospect, N. Y.	43 25 17.949	554.0	73 46 04.570	102.8

## PRIMARY STATIONS.

Azinuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
182 35 25.476	2 36 58.251	Agamenticus .....	68041.91	4.8327765
249 36 12.618	70 12 57.351	Agamenticus .....	77686.65	4.8903464
300 09 32.872	120 44 32.424	Thompson.	81461.91	4.9109540
155 43 45.770	335 24 30.537	Unkoononuc .....	94078.56	4.9734907
215 21 29.380	35 37 02.480	Thompson.	54491.94	4.7363323
203 54 04.099	24 06 13.358	Unkoononuc .....	60093.82	4.7788298
295 31 38.891	116 02 52.610	Blue Hill	70700.04	4.8494197
336 14 24.474	156 23 24.577	Wachusett .....	45164.53	4.6547975
252 07 57.590	72 29 12.028	Unkoononuc.	44548.68	4.6488348
246 05 57.988	66 36 45.098	Wachusett .....	68470.37	4.8355027
212 37 17.232	32 59 12.085	Monadnock.	81877.61	4.9131652
128 48 17.330	308 30 11.049	Mount Tom .....	47662.88	4.6781803
204 05 01.004	24 17 34.496	Wachusett.	62740.03	4.7975447
162 03 16.319	341 55 31.984	Mount Tom .....	51616.87	4.7127917
227 47 14.069	47 57 32.578	Bald Hill.	28797.56	4.4593557
227 27 39.231	47 47 20.351	Box Hill .....	55707.02	4.7459099
196 00 11.934	16 12 15.370	Mount Tom.	90171.62	4.9550699
333 14 07.820	153 25 05.059	Sandford .....	50949.29	4.7071382
276 52 14.769	97 23 00.053	Box Hill.	64330.97	4.8084201
146 50 05.792	326 32 28.490	Wachusett .....	65656.70	4.8172790
228 55 19.774	49 08 50.124	Blue Hill.	36777.41	4.5655811
123 44 56.597	303 35 35.905	Beaconpole .....	23223.72	4.3659318
192 54 36.214	12 58 43.781	Blue Hill.	37951.70	4.5792312
133 18 14.851	313 02 37.562	Beaconpole .....	44425.23	4.6476297
175 17 06.299	355 14 55.237	Blue Hill.	54694.51	4.7379437
2 34 36.135	182 34 11.112	Great Meadow .....	19193.11	4.2831454
72 44 05.443	252 34 18.759	Beaconpole.	21123.09	4.3247575
207 47 11.966	27 51 06.916	Mass. North Base .....	17326.376	4.2387077
126 46 54.940	306 41 03.861	Beaconpole.	15091.32	4.1787273
59 44 30.308	239 25 44.316	Copecut .....	45185.59	4.6550000
126 18 34.859	305 57 32.162	Blue Hill.	53642.95	4.7295127
253 35 57.679	74 19 02.804	Monadnock .....	90121.17	4.9548268
315 41 37.385	136 02 35.298	Mount Tom.	61186.51	4.7866557
292 01 23.100	112 42 40.752	Monadnock .....	88939.22	4.9490933
3 54 40.434	183 52 50.335	Greylock.	58886.79	4.7700179
224 01 02.231	44 21 26.671	Mount Equinox .....	58390.01	4.7663386
294 27 18.781	114 45 37.465	Greylock.	40539.34	4.6078766
154 43 48.875	334 34 13.448	Mount Rafinesque .....	45258.32	4.6556985
216 06 22.198	36 15 02.456	Greylock.	29757.38	4.4735946
188 10 18.052	8 12 39.685	Mount Rafinesque .....	33432.70	4.5241714
287 47 03.641	107 58 58.575	Perry's Peak.	25429.20	4.4053327
240 47 42.718	61 03 45.635	Mount Rafinesque .....	36965.44	4.5677959
268 49 12.873	89 23 31.424	Greylock.	69261.34	4.8404909
298 02 50.279	118 29 36.200	Mount Equinox .....	59941.35	4.7777265
349 59 10.459	170 05 23.401	Mount Rafinesque.	71335.75	4.8533073



## SECONDARY STATIONS.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Patuccawa, N. H.	43 07 13.689	422.5	71 11 51.318	1160.1
Isles of Shoals, N. H., astronomical latitude station, 1847.	42 59 14.862	458.6	70 36 50.285	1139.2
Hampton Falls, N. H.	42 54 44.372	1369.2	70 53 51.877	1176.7
Holt (C. & G. S. & B.).	42 38 28.026	864.8	71 06 24.872	566.7
Powow.	42 51 57.006	1758.9	70 56 18.812	427.0
Orne.	42 30 10.264	316.7	70 57 54.451	1243.1
Prospect Rowley (C. & G. S. & B.).	42 42 19.154	591.0	70 53 33.128	754.0
Prospect Waltham (C. & G. S. & B.).	42 23 18.831	581.0	71 15 15.333	350.7
Powderhorn.	42 24 04.683	144.5	71 01 52.006	1189.3
Cambridge Observatory, center of dome. Telegraphic longitude station, 1851 and 1872.	42 22 53.490	1650.6	71 07 43.885	1003.9
Corey.	42 20 33.376	1029.9	71 08 02.199	50.3
Nantasket.	42 18 15.690	484.1	70 54 20.203	462.8
Indian, astronomical azimuth station, 1845 (C. & G. S. & B.).	41 25 46.744	1442.0	70 40 40.699	945.0
Shootflying, astronomical azimuth station, 1845.	41 41 07.334	226.2	70 20 49.738	1150.3
Nantucket Cliff.	41 17 35.813	1104.8	70 06 53.793	1251.6
Sampson.	41 22 41.830	1290.4	70 29 02.471	57.4
Hyannis (C. & G. S. & B.).	41 37 53.339	1645.5	70 18 26.666	617.3
Nantucket (Great Point) light-house, 1835-'75 (C. & G. S. & B.).	41 23 24.345	751.1	70 02 46.056	1070.0
Cape Poge light-house, 1845-'75.	41 25 16.028	494.5	70 27 05.704	132.4
Spencer, R. I., astronomical azimuth station, 1844.	41 40 43.256	1334.4	71 29 40.685	941.0
Quaker, R. I. (C. & G. S. & B.).	41 34 57.376	1770.1	71 15 18.337	424.7
Pocasset, R. I. (C. & G. S. & B.).	41 39 09.420	290.6	71 11 32.364	748.9
Cuttyhunk (C. & G. S. & B.).	41 25 14.887	459.3	70 56 02.646	61.4

## SECONDARY STATIONS.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
254 15 15.37	74 35 59.52	Agamenticus .....	42638.85	4.6298055
64 34 34.63	244 18 33.40	Unkonoonuc.	35323.24	4.5480605
12 53 01.04	192 48 16.44	Thompson .....	42819.83	4.6316450
166 19 50.29	346 16 37.16	Agamenticus.	26990.73	4.4312146
205 44 26.82	25 52 51.44	Agamenticus .....	38401.12	4.5843439
133 30 41.93	313 18 25.53	Patuccawa.	33647.75	4.5269560
0 45 57.22	180 45 38.49	Blue Hill .....	47647.90	4.6780438
275 55 18.82	96 10 36.93	Thompson.	31066.38	4.4922906
328 48 07.28	148 56 36.04	Thompson .....	32986.27	4.5183332
28 57 40.16	208 50 48.74	Holt.	28515.06	4.4550743
142 53 16.06	322 47 30.75	Holt .....	19272.40	4.2849357
237 50 41.09	58 00 12.78	Thompson.	22757.45	4.3571235
307 59 01.76	128 05 37.47	Thompson .....	16887.32	4.2275607
14 51 34.25	194 48 37.35	Orne.	23266.58	4.3667326
329 30 20.54	149 35 58.86	Blue Hill .....	22723.08	4.3564673
20 24 11.44	200 16 17.33	Beaconpole.	46606.15	4.6684432
85 40 19.75	265 31 18.12	Prospect Waltham .....	18427.94	4.2654767
18 10 41.64	198 07 19.29	Blue Hill.	22104.06	4.3444721
94 22 19.77	274 17 15.44	Prospect Waltham .....	10356.65	4.0152191
356 25 24.69	176 25 59.18	Blue Hill.	18844.17	4.2751770
232 22 39.62	52 26 49.11	Powderhorn .....	10688.86	4.0289312
117 17 35.42	297 12 43.55	Prospect Waltham.	11148.73	4.0472255
59 22 52.32	239 14 26.33	Blue Hill .....	20055.70	4.3022378
156 11 49.30	336 03 39.97	Holt.	40906.81	4.6117956
187 25 18.24	7 28 46.08	Manomet .....	55755.26	4.7462858
135 30 04.33	315 20 51.24	Copecut.	45458.21	4.6576123
44 17 20.61	224 04 10.56	Indian .....	39601.75	4.5977144
143 03 20.31	322 53 34.76	Manomet.	33673.18	4.5272841
156 04 20.29	335 55 06.49	Shootflying .....	47668.76	4.6782338
108 00 24.87	287 38 05.47	Indian.	49486.52	4.6944869
286 52 09.96	107 06 47.50	Nantucket Cliff .....	32305.24	4.5092730
109 26 33.38	289 18 51.59	Indian.	17192.59	4.2353414
151 03 58.99	331 02 23.89	Shootflying .....	6839.50	3.8350247
27 43 48.12	207 36 46.78	Sampson.	31752.19	4.5017737
28 12 03.52	208 09 19.88	Nantucket Cliff .....	12197.72	4.0862788
142 38 50.92	322 26 52.32	Shootflying.	41309.46	4.6160495
92 56 29.40	272 47 30.16	Indian .....	18948.38	4.2775721
207 12 12.72	27 17 56.82	Ilyannis.	26280.49	4.4196335
185 57 36.34	5 59 22.68	Beaconpole .....	35339.35	4.5482586
262 22 17.91	82 39 38.36	Copecut.	36475.19	4.5619976
226 24 37.79	46 32 24.14	Copecut .....	22393.41	4.3501202
118 12 27.73	298 02 54.85	Spencer.	22634.29	4.3547668
150 41 04.12	330 30 44.69	Beaconpole .....	43666.53	4.6401487
235 09 32.46	55 14 48.84	Copecut.	13397.89	4.1270365
123 56 41.52	303 43 55.71	Quaker .....	32270.72	4.5088086
162 33 26.03	342 28 24.78	Copecut.	35009.26	4.5441829

## SECONDARY STATIONS—Continued.

Station.	Latitude.	Seconds in metres.	Longitude	Seconds in metres.
	° ' "		° ' "	
Nootas.	41 32 13.020	401.6	71 07 25.832	598.8
East Rock, R. I.	41 27 04.650	143.4	71 11 38.340	889.9
Mount Hope, R. I.	41 40 26.130	806.1	71 14 26.209	606.2
McSparran, R. I.	41 29 46.953	1448.5	71 27 24.737	573.7
French's Hill (C. & G. S. & B.)	42 25 38.470	1187.0	73 02 16.447	375.9
Bald Peak (or Mount Washington or Mount Everett or Taughanuc Mount or Dome Peak), (C. & G. S. & B.).	42 06 07.301	225.3	73 25 59.109	1358.2

## COAST NORTH OF CAPE ANN.

Great Boar's Head, N. H.	42 55 05.432	167.6	70 47 45.932	1041.8
Seabrook, N. H.	42 52 29.586	913.0	70 49 06.554	148.8
Old Town.	42 46 07.582	234.0	70 51 00.902	20.5
Crane Neck.	42 46 13.667	421.8	70 58 31.748	721.8
Tilton.	42 40 53.162	1640.4	70 47 34.478	784.9
Hampton, N. H.	42 56 33.94	1047.3	70 49 37.92	859.8
Batt's Hill.	42 52 15.86	489.5	70 53 32.60	739.9
Powow (Borden).	42 51 57.08	1761.3	70 56 18.76	425.9
Amesbury Mills, tall white spire.	42 51 21.38	659.8	70 55 58.58	1329.9
Bartlett.	42 50 04.46	137.6	70 55 23.74	539.2
Salisbury Beach.	42 50 49.10	1515.1	70 49 03.44	78.1
Salisbury Marsh.	42 51 06.88	212.3	70 50 11.66	264.7
Salisbury Marsh (Borden).	42 52 18.68	576.4	70 49 14.68	333.2
Salisbury church.	42 50 33.98	1048.6	70 51 38.96	884.7
West Salisbury, powder-house.	42 51 22.08	681.4	70 54 51.36	1166.0

## SECONDARY STATIONS—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
309 04 33.44	129 12 05.94	Cuttyhunk -----	20436.54	4.3104073
156 03 33.63	336 00 49.97	Pocasset.	14058.13	4.1479275
160 44 27.59	340 42 01.77	Quaker -----	15450.37	4.1889388
278 46 25.33	98 56 44.56	Cuttyhunk.	21986.15	4.3421491
6 47 22.05	186 46 47.42	Quaker -----	10213.98	4.0091950
300 27 25.96	120 29 21.52	Pocasset.	4666.63	3.6690033
171 10 21.59	351 08 51.35	Spencer -----	20491.06	4.3115644
240 18 12.34	60 26 14.04	Quaker.	19370.85	4.2871487
155 40 41.39	335 35 28.62	Greylock -----	25595.11	4.4081569
88 41 00.95	268 27 09.60	Perry's Peak.	28181.49	4.4499639
155 21 59.47	335 12 14.80	Yellow Ping -----	47600.92	4.6776154
187 00 04.08	7 02 12.09	Perry's Peak.	35699.39	4.5526608

## COAST NORTH OF CAPE ANN.

193 56 11.7	14 00 26.5	Agamenticus -----	34954.4	4.543502
242 33 32.4	62 40 59.1	Isles of Shoals.	16737.2	4.223682
233 05 42.0	53 14 03.5	Isles of Shoals -----	20860.3	4.319320
84 11 25.5	264 06 31.4	Powow.	9863.0	3.994007
26 10 38.5	206 08 55.2	Prospect Rowley -----	7853.3	3.895050
146 12 55.1	326 09 19.0	Powow.	12977.7	4.113199
316 47 00.5	136 50 23.1	Prospect Rowley -----	9925.0	3.996732
195 53 51.7	15 55 22.0	Powow.	11016.7	4.042051
296 29 39.7	116 35 29.4	Railcut -----	13139.7	4.118587
326 28 15.6	146 30 48.2	Thompson.	9297.5	3.968368
317 04 32	137 05 48	Great Boar's Head -----	3729.9	3.57170
59 36 12	239 33 19	Hampton Falls.	6677.5	3.82468
174 32 49	354 32 36	Hampton Falls -----	4603.8	3.66312
81 15 08	261 13 15	Powow.	3817.5	3.58178
317 59 17	138 11 03	Railcut -----	35420.8	4.549258
348 03 49	168 05 42	Prospect Rowley.	18226.7	4.260709
325 02 26	145 05 48	Old Town -----	11811.4	4.07230
348 48 32	168 50 11	Prospect Rowley.	17055.3	4.23186
320 43 14	140 46 13	Old Town -----	9439.5	3.97495
30 58 23	210 56 15	Crane Neck.	8304.8	3.91933
178 42 06	358 42 04	Seabrook -----	3101.8	3.49162
102 00 42	281 55 46	Powow.	10104.2	4.00450
210 04 18	30 05 02	Seabrook -----	2949.2	3.46970
289 30 46	109 31 32	Salisbury Beach.	1643.1	3.21567
332 31 48	152 38 46	Railcut -----	30443.5	4.483494
17 38 24	197 35 29	Prospect Rowley.	19410.3	4.288032
353 59 33	173 59 59	Old Town -----	8265.9	3.91729
111 59 08	291 55 58	Powow.	6850.3	3.83571
118 30 16	298 29 17	Powow -----	2258.9	3.35390
192 11 45	12 12 25	Hampton Falls.	6386.8	3.80528

## COAST NORTH OF CAPE ANN—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
West Salisbury, church.	42 50 39.64	1223.3	70 55 01.21	231.8
Brandybrow (Borden), N. H.	42 50 00.04	1.2	71 03 16.19	367.7
Morrill.	42 49 15.65	483.0	70 51 06.50	147.6
Mouth of Merrimac, chimney of house.	42 49 13.63	420.7	70 49 18.14	412.0
Newbury, Belleville church.	42 49 06.77	208.9	70 53 24.84	564.3
Newbury, Upper Green church.	42 47 58.56	1807.1	70 51 46.19	1050.5
Newburyport, Pleasant street Unitarian church.	42 48 38.42	1185.6	70 52 19.21	436.4
Newburyport, Harris street church.	42 48 31.71	978.6	70 52 23.74	539.4
Newburyport, Federal street church.	42 48 30.56	943.1	70 51 59.57	1353.4
Newburyport Academy.	42 48 31.79	981.1	70 52 28.89	656.4
Newburyport, beacon on north pier.	42 48 49.26	1520.1	70 51 28.43	645.9
Newburyport light-house (Borden), 1834.	42 48 28.98	894.3	70 48 48.39	1099.5
Newburyport, east light-house, 1850-'51.	42 48 26.93	831.0	70 49 01.34	30.4
Newburyport, west light-house, 1850-'51.	42 48 26.90	830.0	70 49 06.92	157.2
Newburyport light-house, 1878.	42 48 54.76	1689.8	70 49 10.42	236.7
Upper Harbor, inner beacon, 1878.	42 48 40.70	1255.9	70 51 59.70	1356.2
Upper Harbor, outer beacon, 1878.	42 48 41.70	1286.8	70 51 55.25	1255.2
Bailey's wharf.	42 48 42.94	1325.0	70 51 56.55	1284.7
Ayer's Hill (Borden).	42 48 23.28	718.4	71 03 27.81	631.9
Indian Hill, flagstaff, 1878.	42 47 03.22	99.4	70 56 54.40	1236.4
Thompson's Hotel.	42 47 57.15	1763.6	70 48 48.56	1103.4
Old Town church spire.	42 47 58.49	1804.9	70 51 46.19	1049.5
Plum Island magnetic station.	42 47 59.94	1849.7	70 48 49.34	1121.1

## COAST NORTH OF CAPE ANN.—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
25 15 22	205 15 07	Bartlett.....	1200. 0	3. 07918
143 35 01	323 34 08	Powow.	2966. 9	3. 47231
11 22 53	191 20 45	Holt.....	21780. 3	4. 338064
5 03 15	185 03 12	Ayer's Hill.	2996. 7	3. 476642
358 44 26	178 44 30	Old Town.....	5804. 8	3. 76379
125 06 07	305 02 35	Powow.	8665. 2	3. 93778
22 08 37	202 07 27	Old Town.....	6197. 8	3. 79224
117 51 47	297 47 01	Powow.	10801. 4	4. 03348
52 35 04	232 31 36	Crane Neck.....	8785. 4	3. 94376
143 04 17	323 02 19	Powow.	6573. 1	3. 81777
70 41 32	250 36 57	Crane Neck.....	9769. 7	3. 98988
139 56 46	319 53 41	Powow.	9616. 6	3. 98302
8 10 47	188 09 57	Prospect Rowley.....	11823. 3	4. 07274
62 13 10	242 08 57	Crane Neck.	9572. 8	3. 98104
63 02 46	242 58 36	Crane Neck.....	9386. 2	3. 97249
337 02 47	157 03 43	Old Town.	4829. 5	3. 68390
167 32 48	347 31 32	Hampton Falls.....	11813. 5	4. 07238
205 16 05	25 18 58	Great Boar's Head.	13476. 9	4. 12959
170 42 05	350 41 09	Hampton Falls.....	11650. 4	4. 06634
207 50 37	27 53 49	Great Boar's Head.	13740. 7	4. 13801
352 50 58	172 51 17	Old Town.....	5027. 9	3. 70139
131 19 43	311 16 26	Powow.	8777. 7	3. 94338
325 59 24	146 06 04	Railcut.....	24035. 6	4. 380855
29 35 49	209 32 36	Prospect Rowley.	13120. 8	4. 117961
32 18 10	212 16 49	Old Town.....	5086. 5	3. 70642
123 09 53	303 04 55	Powow.	11862. 6	4. 07418
31 04 59	211 03 42	Old Town.....	5019. 3	3. 70064
123 30 20	303 25 26	Powow.	11757. 4	4. 07031
25 57 49	205 56 34	Old Town.....	5737. 3	3. 75871
120 04 20	299 59 29	Powow.	11237. 0	4. 05065
135 51 21	315 48 25	Powow.....	8445. 2	3. 92661
228 14 48	48 15 24	Morrill.	1619. 8	3. 20945
73 07 48	253 07 45	Upper Harbor, inner beacon.....	105. 5	2. 02338
226 34 43	46 35 16	Morrill.	1524. 5	3. 18314
46 00 06	226 00 04	Upper Harbor, inner beacon.....	99. 4	1. 99760
322 33 14	142 33 15	Upper Harbor, outer beacon.	48. 4	1. 68518
309 39 56	129 46 40	Prospect Rowley.....	17581. 9	4. 245066
12 23 13	192 21 13	Holt.	18804. 4	4. 274260
282 01 28	102 05 28	Old Town.....	8217. 5	3. 91474
185 05 33	5 05 57	Powow.	9101. 9	3. 95913
41 40 13	221 38 43	Old Town.....	4525. 4	3. 65566
125 56 23	305 51 17	Powow.	12623. 5	4. 10118
190 21 38	10 23 05	Hampton.....	16170. 4	4. 20872
202 28 08	22 30 51	Great Boar's Head.	14258. 7	4. 15408
40 47 12	220 45 43	Old Town.....	4578. 7	3. 66074
125 40 04	305 34 58	Powow.	12558. 8	4. 09895

## COAST NORTH OF CAPE ANN—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Plum Island 1.	42 46 37.02	1142.4	70 48 17.72	402.8
Plum Island 2.	42 44 27.80	857.8	70 47 33.78	768.4
Little Old Town.	42 46 24.87	767.4	70 50 32.24	732.9
Dummer Academy.	42 45 16.29	502.7	70 53 59.58	1354.9
Wood's Hotel.	42 45 23.87	736.6	70 48 15.60	354.7
Poplar Hill (Borden).	42 44 06.22	191.9	71 15 22.10	502.7
Poplar Hill, stone monument (Borden).	42 44 11.56	356.7	71 15 20.30	461.8
Ox Pasture Hill.	42 44 17.08	527.0	70 52 55.00	1251.1
Rowley Marsh.	42 44 37.76	1165.2	70 50 16.33	371.4
Rowley church spire with turrets.	42 42 59.02	1821.2	70 52 42.38	964.2
Byfield church, square tower.	42 44 19.04	587.5	70 55 53.81	1224.0
Gumpus (Borden), N. H.	42 43 32.91	1015.5	71 21 46.61	1060.5
Ipswich Town Farm.	42 43 03.92	121.0	70 50 52.09	1185.3
Proctor's barn.	42 43 02.03	62.6	70 46 51.52	1172.3
Manning's Hill.	42 42 30.26	933.8	70 48 23.32	530.6
Lowell church (Borden).	42 38 48.03	1482.0	71 19 06.70	151.6
Marsh & Jones (Borden).	42 42 43.81	1351.9	71 18 11.19	254.6
Pine Tree Boundary, stone monument (Borden).	42 41 50.26	1550.9	71 19 22.02	501.2

## VICINITY OF CAPE ANN.

Railcut (C. & G. S. & B).	42 37 42.872	1322.7	70 38 58.400	1330.6
Poole's Hill.	42 39 24.690	762.0	70 38 05.772	131.6
Andrews' Point.	42 40 58.98	1819.9	70 37 46.80	1065.4
Lane's Cove, white spire.	42 40 41.55	1282.1	70 39 15.88	361.5

## COAST NORTH OF CAPE ANN—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / ' "	° / ' "		<i>Metres.</i>	
354 42 01	174 42 30	Tilton .....	10655.9	4. 02759
76 15 24	256 13 33	Old Town.	3819. 1	3. 58196
0 08 24	180 08 24	Tilton .....	6623. 4	3. 82108
64 08 09	244 04 05	Prospect Rowley.	9088. 7	3. 95850
88 13 40	268 08 14	Crane Neck .....	10906. 9	4. 03770
50 42 39	230 42 20	Old Town.	842. 1	2. 92536
105 59 33	285 56 28	Crane Neck .....	6437. 1	3. 80869
353 42 48	173 43 06	Prospect Rowley.	5499. 0	3. 74028
353 36 21	173 36 49	Tilton .....	8405. 4	3. 92456
51 45 19	231 41 44	Prospect Rowley.	9201. 5	3. 96386
310 25 20	130 31 25	Holt .....	16077. 5	4. 206219
243 53 52	64 01 57	Ayer's Hill.	18072. 9	4. 257029
13 57 38	193 57 37	Poplar Hill .....	169. 6	2. 22936
115 11 39	295 07 50	Crane Neck .....	8461. 0	3. 92742
13 24 47	193 24 21	Prospect Rowley.	3740. 8	3. 57296
331 59 52	152 01 42	Tilton .....	7848. 4	3. 89478
46 19 49	226 17 35	Prospect Rowley.	6192. 1	3. 79184
298 57 47	119 01 16	Tilton .....	8012. 2	3. 90375
43 12 04	223 11 30	Prospect Rowley.	1687. 3	3. 22720
243 16 39	63 19 58	Old Town .....	7455. 9	3. 87250
319 07 10	139 08 45	Prospect Rowley.	4891. 8	3. 68947
250 09 53	70 22 19	Ayer's Hill .....	26540. 4	4. 423908
294 03 36	114 14 01	Holt.	22998. 5	4. 361700
177 58 34	357 58 28	Old Town .....	5670. 7	3. 75364
69 21 42	249 19 53	Prospect Rowley.	3916. 3	3. 59288
81 47 59	261 43 27	Prospect Rowley .....	9234. 9	3. 96543
135 17 28	315 14 39	Old Town.	8059. 5	3. 90631
339 38 26	159 38 59	Tilton .....	3196. 1	3. 50462
87 14 38	267 11 08	Prospect Rowley.	7059. 1	3. 84875
157 31 24	337 29 36	Gumpus .....	9514. 5	3. 978387
271 57 58	92 06 34	Holt.	17365. 8	4. 239695
107 11 57	287 09 31	Gumpus .....	5130. 2	3. 71014
9 51 48	189 51 10	Lowell church.	7384. 6	3. 86833
133 55 29	313 53 51	Gumpus .....	4567. 2	3. 65965
224 16 58	44 17 46	Marsh & Jones.	2308. 3	3. 36328

## VICINITY OF CAPE ANN.

74 10 58.4	254 07 41.5	Thompson .....	6888. 2	3. 838105
113 15 06.7	293 05 13.9	Prospect Rowley.	21667. 7	4. 335812
20 53 33.8	200 52 58.1	Railcut .....	3362. 8	3. 526702
57 20 06.2	237 16 13.6	Thompson.	9297. 4	3. 968362
117 52 03	297 43 04	Old Town .....	20422. 6	4. 31011
89 17 09	269 10 31	Tilton.	13380. 8	4. 12648
40 07 29	220 04 24	Thompson .....	9666. 4	3. 98526
91 51 18	271 45 40	Tilton.	11358. 0	4. 05530



## VICINITY OF CAPE ANN—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Choate.	42 39 55.52	1713.2	70 45 40.80	929.1
Ipswich light-house, 1849.	42 41 06.81	210.1	70 46 07.32	166.6
Ipswich Beacon, 1849.	42 41 07.56	233.3	70 45 59.91	1363.9
Ipswich, tall dark spire.	42 40 53.18	1641.1	70 50 11.70	266.3
Butler's Hill.	42 39 29.50	910.3	70 40 18.33	417.5
Burnham Brown, flag.	42 39 32.00	987.4	70 49 25.88	589.5
Burnham Essex, flag in tree.	42 39 01.50	46.3	70 47 04.48	102.0
Annisquam Harbor light-house (C. & G. S. & B.), 1834-49.	42 39 43.02	1327.4	70 40 55.29	1258.1
Annisquam, pole on rock.	42 39 26.92	830.7	70 40 39.62	902.4
Straitsmouth light-house, 1849.	42 39 43.65	1346.8	70 35 22.52	512.9
Straitsmouth light-house, 1851.	42 39 44.37	1369.0	70 35 19.15	436.1
Twopenny Loaf, flag.	42 39 36.80	1135.5	70 43 08.84	201.3
Rockport, red top church.	42 39 28.80	888.7	70 37 09.70	220.9
Dogtown, Methodist church.	42 38 04.86	149.9	70 40 33.09	754.0
Lufkin's Hill, flag.	42 38 16.08	496.1	70 44 40.86	930.9
Londoner Beacon, 1849.	42 38 06.26	193.1	70 33 59.33	1351.7
Essex powder-house.	42 38 19.16	591.2	70 47 18.24	415.6
Essex, red top church.	42 37 59.96	1850.1	70 46 53.16	1211.2
Beacon Hill 1.	42 36 24.94	769.6	70 38 43.01	980.3
Beacon Hill 2.	42 36 11.74	362.2	70 38 38.64	880.9
Beacon Hill, magnetic station, 1849.	42 36 22.79	703.3	70 38 46.85	1067.9
Thatcher's Island.	42 38 10.94	337.5	70 34 46.28	1054.5
Salvage.	42 40 20.24	624.6	70 34 05.94	135.2

## VICINITY OF CAPE ANN—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
294 01 26	114 05 59	Railcut .....	10039. 2	4. 00170
336 55 35	156 56 51	Thompson.	6492. 7	3. 81243
344 38 59	164 39 17	Choate .....	2281. 2	3. 35816
78 01 26	258 00 27	Tilton.	2028. 7	3. 30721
340 01 03	160 02 32	Thompson .....	8721. 2	3. 94058
78 21 25	258 20 21	Tilton.	2198. 5	3. 34213
311 37 23	131 41 42	Thompson .....	11664. 3	4. 06686
6 31 01	186 30 35	Brown's Hill.	7686. 5	3. 88573
331 01 55	151 02 49	Railcut .....	3760. 6	3. 57526
42 54 41	222 52 18	Thompson.	7057. 8	3. 84867
225 21 25	45 22 40	Tilton .....	3564. 6	3. 55201
304 20 44	124 24 32	Thompson.	9294. 8	3. 96824
228 49 06	48 50 03	Choate .....	2532. 0	3. 40346
314 02 40	134 04 52	Thompson.	6193. 3	3. 79192
35 21 06	215 19 08	Thompson .....	6849. 8	3. 83568
103 25 49	283 21 19	Tilton.	9343. 9	3. 97053
324 18 14	144 19 23	Railcut .....	3953. 0	3. 59693
40 19 23	220 17 15	Thompson.	6676. 4	3. 82454
81 04 12	261 02 21	Poole's Hill .....	3764. 1	3. 57566
125 17 43	305 16 05	Andrews' Point.	4024. 5	3. 60471
80 55 13	260 53 20	Poole's Hill .....	3843. 2	3. 58469
124 25 05	304 23 25	Andrews' Point.	4074. 6	3. 61009
9 39 48	189 39 21	Thompson .....	5474. 0	3. 73830
99 29 15	279 27 32	Choate.	3508. 5	3. 54512
84 19 39	264 19 01	Poole's Hill .....	1283. 3	3. 10832
163 07 15	343 06 50	Andrews' Point.	2908. 2	3. 46362
287 26 43	107 27 47	Railcut .....	2261. 6	3. 35442
187 19 55	7 20 05	Butler's Hill.	2633. 5	3. 42054
337 55 11	157 55 46	Thompson .....	3135. 2	3. 49626
71 41 23	251 37 13	Brown's Hill.	8861. 9	3. 94752
83 59 02	263 55 39	Railcut .....	6852. 4	3. 83584
113 20 43	293 17 56	Poole's Hill.	6113. 3	3. 78628
175 33 02	355 32 51	Tilton .....	4766. 3	3. 67818
216 44 04	36 45 10	Choate.	3710. 2	3. 56940
252 53 13	72 57 40	Butler's Hill .....	9408. 9	3. 97354
299 51 08	119 53 13	Thompson.	4835. 3	3. 68442
171 42 10	351 42 00	Railcut .....	2430. 3	3. 38566
94 19 15	274 15 48	Thompson.	6997. 9	3. 84497
170 54 12	350 53 59	Railcut .....	2847. 7	3. 45449
97 31 25	277 27 55	Thompson.	7138. 9	3. 85363
232 48 30	52 48 33	Beacon Hill 1. ....	109. 81	2. 04064
81 26 49	261 23 58	Railcut .....	5809. 3	3. 76412
55 14 21	235 11 44	Beacon Hill 2.	6447. 7	3. 80940
12 58 08	192 57 41	Thatcher's Island .....	4093. 8	3. 61213
72 35 49	252 33 06	Poole's Hill.	5724. 3	3. 75772

## VICINITY OF CAPE ANN—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Cape Ann north light-house (C. & G. S. & B.), 1834-'49.	42 38 21.29	657.1	70 34 31.03	707.0
Cape Ann north light-house, 1878.	42 38 21.25	655.8	70 34 31.05	707.4
Cape Ann south light-house (C. & G. S. & B.), 1834-'49.	42 38 12.82	395.5	70 34 31.68	721.8
Cape Ann south light-house, 1878.	42 38 12.82	395.5	70 34 31.78	724.1
Milk Island, flag.	42 37 41.64	1284.8	70 35 31.80	724.6
Salt Island, flag.	42 37 11.38	351.1	70 37 26.60	606.3
Gloucester, east church.	42 37 00.46	14.2	70 39 25.66	584.9
Gloucester, Universalist church.	42 36 47.66	1470.6	70 40 00.14	3.2
Woodward's Hill, flag.	42 36 59.74	1843.2	70 42 05.96	135.8
Clark's mountain, flag in tree.	42 36 59.50	1836.0	70 43 41.16	938.0
Ten Pound Island light-house, 1849.	42 36 06.66	205.5	70 39 57.58	1312.6
Eastern Point light-house (C. & G. S. & B.), 1834-'49.	42 34 49.14	1516.2	70 39 53.90	1229.1

## VICINITY OF SALEM.

Brown's Hill.	42 36 45.688	1409.7	70 50 49.984	1139.3
Coddon (C. & G. S. & B.).	42 30 59.166	1825.7	70 51 17.520	399.9
Bolles.	42 35 05.95	183.6	70 47 35.44	808.3
Folly Hill.	42 33 59.12	1824.3	70 54 48.20	1099.3
Beverly Rocks.	42 33 58.78	1813.8	70 50 14.98	341.7
Beverly, powder-house.	42 33 12.60	388.7	70 52 33.13	755.9
Beverly, tall spire with turrets.	42 32 51.06	1575.6	70 52 43.52	993.8
Beverly Point, flag in tree.	42 32 59.04	1821.8	70 54 15.46	352.7
Baker's Island light-house (C. & G. S. & B.) 1834-'77.	42 32 11.53	355.8	70 47 11.22	256.1
Kettle Island.	42 34 01.26	38.9	70 43 22.00	501.8
Fort Lee.	42 31 54.71	1688.2	70 52 28.94	660.4

## VICINITY OF CAPE ANN—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
79 00 49	258 57 48	Railcut .....	6206. 4	3. 79284
111 49 03	291 46 38	Poole's Hill.	5268. 1	3. 72165
58 00 48	237 57 57	Beacon Hill 1 .....	6771. 3	3. 83067
111 50 05	291 47 40	Poole's Hill.	5268. 4	3. 72168
81 22 42	261 19 41	Railcut .....	6147. 2	3. 78868
114 28 16	294 25 51	Poole's Hill.	5357. 3	3. 72895
59 50 47	239 47 57	Beacon Hill 1 .....	6622. 8	3. 82104
114 29 05	294 26 40	Poole's Hill.	5355. 6	3. 72881
90 28 57	270 26 37	Railcut .....	4707. 5	3. 67279
56 56 22	236 54 15	Beacon Hill 2.	5082. 3	3. 70606
114 54 59	294 53 57	Railcut .....	2306. 4	3. 36294
41 44 50	221 44 01	Beacon Hill 2.	2466. 5	3. 39208
84 35 10	264 32 12	Thompson .....	6033. 0	3. 78053
205 23 24	25 23 42	Railcut.	1448. 8	3. 16102
175 15 22	355 15 10	Butler's Hill .....	5011. 4	3. 69996
219 32 31	39 33 13	Railcut.	2209. 6	3. 34432
207 56 25	27 57 38	Butler's Hill .....	5231. 4	3. 71862
252 41 17	72 43 24	Railcut.	4476. 5	3. 65094
143 37 28	323 34 50	Tilton .....	8956. 9	3. 95216
258 14 39	78 17 50	Railcut.	6581. 3	3. 81831
204 25 45	24 26 25	Railcut .....	3260. 8	3. 51332
265 00 51	85 01 44	Beacon Hill 2.	1806. 3	3. 25678
228 21 47	48 25 15	Thatcher's Island .....	9377. 6	3. 97209
193 16 31	13 17 09	Railcut.	5507. 9	3. 74099

## VICINITY OF SALEM.

98 31 09. 8	278 20 36. 7	Holt .....	21536. 5	4. 333174
38 28 34. 0	218 23 46. 9	Orne.	15576. 8	4. 192479
123 52 53. 2	303 42 39. 3	Holt .....	24899. 7	4. 396194
223 59 47. 4	44 04 50. 7	Thompson.	14712. 3	4. 167681
124 46 28	304 44 16	Brown .....	5398. 5	3. 73227
240 07 13	60 09 46	Thompson.	5948. 3	3. 77439
319 05 35	139 07 57	Coddon .....	7344. 5	3. 86596
31 03 47	211 01 41	Orne.	8241. 8	3. 91602
14 26 43	194 26 01	Coddon .....	5723. 0	3. 75762
56 07 28	236 02 18	Orne.	12635. 7	4. 10160
337 14 56	157 15 47	Coddon .....	4464. 3	3. 64975
52 32 04	232 28 26	Orne.	9242. 8	3. 96580
330 22 30	150 23 28	Coddon .....	3971. 5	3. 59895
55 04 17	235 00 47	Orne.	8659. 1	3. 93748
312 18 45	132 20 45	Coddon .....	5493. 0	3. 73981
43 50 40	223 48 12	Orne.	7218. 4	3. 85844
68 21 47	248 19 01	Coddon .....	6048. 7	3. 78166
107 42 21	287 37 12	Folly Hill.	10941. 6	4. 03908
62 40 15	242 34 54	Coddon .....	12218. 0	4. 08700
57 06 08	237 03 33	Baker's Island light-house.	6230. 9	3. 79455
140 23 59	320 22 25	Folly Hill .....	4982. 9	3. 69748
66 35 04	246 31 24	Orne.	8099. 2	3. 90844

## VICINITY OF SALEM—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Legg's Hill.	42 29 23.30	719.0	70 53 30.83	704.0
Manchester church, dark spire.	42 34 30.28	934.3	70 46 20.82	474.8
Danvers Insane Asylum, tower	42 34 51.74	1596.6	70 58 30.82	702.8
Danvers Plain, tall spire.	42 34 03.32	102.5	70 56 18.26	416.5
Danvers, New Mills, tall spire.	42 33 20.70	638.8	70 55 30.55	696.9
South Danvers, tall spire.	42 31 35.38	1091.7	70 55 40.55	925.5
Dexter's Point.	42 32 53.80	1660.1	70 50 44.26	1009.8
Bowditch's Ledge Beacon.	42 32 25.38	783.2	70 48 43.19	985.5
Great Misery, flag.	42 32 50.20	1549.0	70 47 49.23	1123.2
Great Haste.	42 32 05.29	163.3	70 50 32.51	741.9
Little Haste Beacon.	42 32 07.71	237.9	70 50 35.95	820.4
Hardy's Rock Beacon.	42 32 11.36	350.5	70 48 01.62	37.0
Dodge's Hotel, cupola.	42 32 02.86	88.2	70 53 49.30	1125.1
Hospital Point light-house, 1877.	42 32 47.60	1468.8	70 51 23.29	531.3
Fort Pickering light-house, 1877.	42 31 35.57	1097.6	70 52 01.07	24.4
Great Aquavitae, stone beacon.	42 31 34.58	1067.0	70 51 28.24	644.5
Little Aquavitae, pole.	42 31 34.78	1073.2	70 51 13.10	299.0
Abbot's Rock, stone beacon.	42 31 49.48	1526.8	70 51 46.34	1057.5
North Gooseberry Island, flag.	42 31 35.97	1109.9	70 47 39.19	894.4
Eagle Island, flag.	42 31 31.21	963.1	70 48 49.24	1123.8
Coney Island, flag.	42 31 42.89	1323.4	70 50 14.78	337.3
Salem, south church, corner of Cambridge and Chestnut streets.	42 31 12.02	370.9	70 53 59.36	1354.8
Salem, Howard street church.	42 31 28.12	867.7	70 53 34.04	776.9

## VICINITY OF SALEM—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
103 33 33	283 30 35	Orne.....	6191. 7	3. 79181
225 48 19	45 49 49	Coddon.....	4244. 2	3. 62780
46 03 15	225 58 25	Legg's Hill.....	13638. 6	4. 13477
60 16 54	240 12 45	Fort Lee.....	9673. 6	3. 98559
305 56 10	126 01 03	Coddon.....	12216. 0	4. 08693
354 32 21	174 32 46	Orne.....	8724. 9	3. 94076
307 09 31	127 12 06	Fort Lee.....	6566. 6	3. 81734
273 36 19	93 37 20	Folly Hill.....	2058. 4	3. 31352
307 04 40	127 07 31	Coddon.....	7239. 9	3. 85973
29 12 50	209 11 13	Orne.....	6731. 8	3. 82813
195 04 03	15 04 38	Folly Hill.....	4593. 0	3. 66210
280 30 58	100 33 56	Coddon.....	6106. 9	3. 78582
285 00 00	105 02 24	Baker's Island light-house.....	5033. 3	3. 70185
12 06 52	192 06 30	Coddon.....	3617. 2	3. 55837
52 57 21	232 55 37	Coddon.....	4413. 8	3. 64482
79 36 48	259 34 15	Fort Lee.....	5237. 8	3. 71915
54 14 29	234 12 08	Coddon.....	5858. 8	3. 76781
75 00 35	254 57 26	Fort Lee.....	6608. 8	3. 82012
26 43 46	206 43 16	Coddon.....	2284. 0	3. 35869
83 00 24	262 59 05	Fort Lee.....	2676. 9	3. 42764
24 10 03	204 09 35	Coddon.....	2318. 0	3. 36512
81 09 48	261 08 32	Fort Lee.....	2609. 8	3. 41660
85 12 52	265 09 51	Fort Lee.....	6122. 2	3. 78691
109 45 35	289 41 00	Folly Hill.....	9853. 9	3. 99361
159 28 06	339 27 26	Folly Hill.....	3830. 5	3. 58325
277 48 22	97 49 16	Fort Lee.....	1851. 0	3. 26740
357 44 44	177 44 48	Coddon.....	3348. 4	3. 52484
61 30 05	241 25 41	Orne.....	10162. 5	4. 00700
318 28 55	138 29 24	Coddon.....	1499. 8	3. 17603
26 40 14	206 39 13	Legg's Hill.....	4566. 6	3. 65959
347 22 34	167 22 41	Coddon.....	1119. 6	3. 04907
114 08 54	294 08 13	Fort Lee.....	1518. 2	3. 18134
5 14 47	185 14 44	Coddon.....	1103. 4	3. 04275
109 33 29	289 32 38	Fort Lee.....	1836. 8	3. 26407
337 02 09	157 02 28	Coddon.....	1685. 9	3. 22683
27 53 02	207 51 51	Legg's Hill.....	5102. 3	3. 70777
77 11 02	257 08 34	Coddon.....	5111. 4	3. 70854
141 07 20	321 05 35	Beverly Rocks.....	5661. 5	3. 75293
73 43 39	253 41 59	Coddon.....	3526. 1	3. 54730
156 45 24	336 44 26	Beverly Rocks.....	4955. 9	3. 69512
46 43 17	226 42 35	Coddon.....	1967. 2	3. 29384
96 48 27	276 46 56	Fort Lee.....	3083. 5	3. 48904
276 06 36	96 08 25	Coddon.....	3715. 5	3. 57002
349 00 26	169 00 45	Legg's Hill.....	3417. 0	3. 53365
160 02 50	340 02 00	Folly Hill.....	4957. 0	3. 69522
241 04 41	61 05 25	Fort Lee.....	1697. 1	3. 22972

## VICINITY OF SALEM—Continued.

Station.	Latitude. ° ' "	Seconds in metres.	Longitude. ° ' "	Seconds in metres.
Derby's wharf light-house, 1877.	42 30 59.91	1848.7	70 53 02.54	58.0
Marblehead light-house, 1848-'77.	42 30 19.76	609.7	70 50 03.02	68.9
Marblehead, black top church.	42 30 25.66	791.8	70 50 54.11	1235.3
Marblehead Rock Beacon.	42 30 11.95	367.7	70 49 34.48	787.2
Marblehead Neck, flag.	42 29 46.94	1448.7	70 50 29.04	663.1
Cat Island flag-staff, 1848.	42 30 43.52	1342.9	70 48 55.42	1265.1
Cat Island, east rock.	42 30 32.61	1006.2	70 48 45.00	1027.3
Boulder west of Salem turnpike.	42 30 21.92	676.4	70 56 07.38	168.5
Ware's Hill, flag-staff, 1848.	42 30 40.60	1252.7	70 54 32.79	748.5
Halfway Rock Beacon.	42 30 09.38	289.5	70 46 31.40	716.9
Brookhouse's house.	42 29 08.56	264.1	70 53 13.76	314.3
Ocean House, cupola.	42 28 53.73	1658.0	70 52 33.64	768.3
Tinker's Island, pole on house.	42 28 57.71	1780.8	70 50 07.28	166.3
Church spire summer-house.	42 28 55.14	1701.5	70 53 03.45	78.8
Summer-house on high rock.	42 28 05.06	156.2	70 56 48.86	1116.1

## BOSTON BAY.

Nahant.	42 25 04.764	147.0	70 54 18.232	416.8
Dorchester Heights.	42 20 03.428	105.8	71 02 35.910	822.1
Deer Island.	42 21 01.282	39.6	70 57 30.989	709.3
Governor's Island.	42 21 08.312	256.5	71 00 39.030	893.3
Boston State House (C. & G. S. & B.).	42 21 29.596	913.2	71 03 51.040	1168.1
Long Island Head light-house, 1846-1860.	42 19 48.132	1485.0	70 57 24.123	552.3
Powderhorn 2. 1877.	42 24 04.564	140.8	71 01 52.055	1190.5

## VICINITY OF SALEM—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
270 31 50	90 33 01	Coddon .....	2397. 5	3. 37976
12 13 36	192 13 17	Legg's Hill.	3049. 7	3. 48426
125 34 26	305 33 36	Coddon .....	2090. 7	3. 32030
228 39 22	48 41 18	Baker's Island light-house.	5222. 3	3. 71786
87 12 26	267 07 42	Orne .....	9608. 6	3. 98266
140 58 41	320 56 03	Folly Hill.	8480. 5	3. 92842
121 47 05	301 45 55	Coddon .....	2767. 1	3. 44203
134 25 24	314 21 52	Folly Hill.	10019. 6	4. 00085
94 05 21	274 00 20	Orne .....	10195. 5	4. 00841
153 35 42	333 35 09	Coddon.	2488. 3	3. 39590
98 29 02	278 27 26	Coddon .....	3279. 9	3. 51586
114 16 59	294 14 35	Fort Lee.	5345. 4	3. 72798
103 15 34	283 13 51	Coddon .....	3577. 1	3. 55354
162 07 16	342 06 15	Beverly Rocks.	6684. 8	3. 82509
260 07 08	80 10 24	Coddon .....	6716. 5	3. 82714
195 04 59	15 05 53	Folly Hill.	6941. 3	3. 84144
262 39 34	82 41 46	Coddon .....	4494. 4	3. 65267
329 19 10	149 19 52	Legg's Hill.	2773. 3	3. 44299
90 09 53	270 02 11	Orne .....	15595. 5	4. 19300
103 15 46	283 12 33	Coddon.	6710. 1	3. 82673
106 34 15	286 31 05	Orne .....	6686. 4	3. 82519
166 29 29	346 28 25	Folly Hill.	9220. 8	3. 96477
204 10 29	24 11 20	Coddon .....	4242. 8	3. 62765
107 53 47	287 50 10	Orne.	7697. 3	3. 88634
99 39 40	279 37 22	Legg's Hill .....	4715. 3	3. 67351
156 50 14	336 49 27	Coddon.	4076. 5	3. 61029
109 15 37	289 12 20	Orne .....	7038. 2	3. 84746
212 16 55	32 18 05	Coddon.	4527. 5	3. 65586
158 48 45	338 48 01	Orne .....	4143. 7	3. 61739
241 53 24	61 55 38	Legg's Hill.	5127. 3	3. 70989

## BOSTON BAY.

37 09 11.4	217 00 43.5	Blue Hill .....	28652. 6	4. 457164
83 37 52.4	263 23 44.7	Prospect Waltham.	28933. 7	4. 461404
23 28 40.0	203 25 47.3	Blue Hill .....	14781. 5	4. 169719
109 12 15.5	289 03 43.8	Prospect Waltham.	18394. 8	4. 264695
40 02 12.6	219 55 54.7	Blue Hill .....	20027. 3	4. 301623
99 59 07.6	279 47 10.3	Prospect Waltham.	24720. 4	4. 393056
162 57 02.7	342 56 13.5	Powderhorn .....	5692. 4	3. 755292
301 31 02.6	121 35 17.7	Nantasket.	10178. 5	4. 007682
209 37 54.4	29 39 14.6	Powderhorn .....	5505. 9	3. 740825
14 24 17.8	194 22 15.6	Blue Hill.	16744. 1	4. 223863
304 05 21.5	124 07 25.3	Nantasket .....	5086. 7	3. 706439
44 55 19.1	224 48 56.7	Blue Hill.	18467. 4	4. 266407
18 10 42.7	198 07 20.4	Blue Hill .....	22100. 3	4. 344397
85 40 59.6	265 31 58.0	Prospect Waltham.	18426. 6	4. 265445



## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Blind Asylum.	42 20 07.037	217.1	71 02 32.861	752.3
White's Hill.	42 12 52.466	1618.8	70 58 39.300	901.4
Great Quincy.	42 16 29.026	895.6	70 57 06.869	157.4
Scituate (C. & G. S. and B.).	42 14 14.646	451.9	70 49 51.228	1174.6
Hayden's Hotel.	42 15 10.370	320.0	70 46 20.130	461.4
Cat Hill.	42 13 19.178	591.8	70 45 20.317	466.0
Blue Hill (Borden).	42 12 43.676	1347.5	71 06 52.709	1209.0
Cambridge Observatory, west transit, astronomical azimuth station, 1867-1869.	42 22 53.481	1650.3	71 07 44.478	1017.4
Cambridge Observatory Meridian mark (east Transit or Meridian Circle), 1845-1847.	42 25 47.43	1463.5	71 07 43.52	994.8
Nahant (Borden).	42 25 40.21	1240.7	70 55 16.96	387.6
Castle Hill (Borden).	42 29 19.54	602.9	71 02 42.12	961.8
Ballard.	42 27 17.56	541.9	70 59 32.57	744.3
Waite 1.	42 26 00.83	25.6	71 03 57.96.	1324.8
Waite 2.	42 26 20.43	630.6	71 01 13.14	300.3
Little Nahant.	42 26 13.27	409.6	70 55 52.09	1190.5
Egg Rock light-house, 1877.	42 26 00.76	23.4	70 53 54.02	1234.7
Dread Ledge Beacon.	42 27 23.19	715.6	70 53 43.54	994.8
Swampscott church.	42 28 06.14	189.4	70 54 58.40	1334.0
Grover's Cliff.	42 23 22.79	703.4	70 58 08.65	197.9
Lynn, east church, green tower.	42 28 07.12	219.7	70 56 16.41	374.9
Lynn, west church, turret.	42 27 45.71	1410.4	70 57 37.00	845.3
Lynn, high rock, pole near swing.	42 28 04.96	153.0	70 56 52.10	1190.2
Egg Rock.	42 26 00.40	12.3	70 53 53.34	1219.2

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Meters.</i>	
108 48 23.3	288 39 49.5	Prospect Waltham .....	18424.5	4. 265397
187 15 23.6	7 15 51.1	Powderhorn 2. ....	7388.2	3. 868539
88 42 52.3	268 37 20.8	Blue Hill .....	11319.1	4. 053812
210 44 56.2	30 47 50.4	Nantasket. ....	11607.3	4. 064731
229 13 32.3	49 15 24.4	Nantasket .....	5040.9	3. 702512
17 36 16.5	197 35 14.4	White's Hill. ....	7009.9	3. 845710
140 22 23.2	320 19 22.3	Nantasket .....	9659.7	3. 984962
78 13 24.3	258 07 29.4	White's Hill. ....	12372.9	4. 092473
70 27 43.3	250 25 21.4	Scituate .....	5136.0	3. 710626
117 40 36.5	297 25 13.5	Nantasket. ....	12397.8	4. 093344
105 25 39.1	285 22 37.0	Scituate .....	6443.9	3. 809150
158 12 59.8	338 12 19.6	Hayden's Hotel. ....	3694.7	3. 567583
116 03 16.0	295 32 02.3	Wachusett .....	70702.2	4. 849433
180 45 45.0	0 46 03.8	Holt. ....	47656.1	4. 678118
268 47.9	88 47.9	Cambridge Observatory (Dome) .....	13.571	1. 13262
291 29 34	111 33 31	Powderhorn .....	8639.7	3. 93650
2 31 33	182 31 20	Corey. ....	9699.3	3. 98674
340 32 58	160 36 37	Scituate .....	22428.5	4. 350801
33 41 13	213 33 25	Blue Hill (Borden). ....	28773.5	4. 458992
327 38 34	147 47 13	Scituate .....	33026.5	4. 518862
10 35 48	190 32 59	Blue Hill (Borden). ....	31257.7	4. 494971
299 39 55	119 43 27	Nahant .....	8270.8	3. 91755
28 11 17	208 09 43	Powderhorn. ....	6751.0	3. 82937
321 12 13	141 13 38	Powderhorn .....	4597.3	3. 66250
358 54 57	178 55 02	Boston State House. ....	8370.3	3. 92274
283 47 28	103 52 08	Nahant .....	9767.9	3. 98980
11 59 02	191 58 36	Powderhorn. ....	4281.9	3. 63164
314 34 00	134 35 03	Nahant .....	3012.0	3. 47886
64 17 28	244 13 25	Powderhorn. ....	9135.7	3. 96074
144 30 58	324 28 16	Orne .....	9457.4	3. 97577
201 12 11	21 13 57	Coddon. ....	9877.3	3. 99464
10 31 16	190 30 53	Nahant .....	4344.1	3. 63790
88 47 00	268 43 04	Ballard. ....	7977.2	3. 90185
19 24 43	199 24 07	Little Nahant .....	3691.9	3. 56725
76 34 05	256 31 00	Ballard. ....	6440.8	3. 80894
348 50 00	168 50 25	Deer Island .....	4450.5	3. 64841
104 13 09	284 10 39	Powderhorn. ....	5269.6	3. 72178
16 18 44	196 17 28	Grover's Cliff .....	9140.5	3. 96097
71 10 38	251 08 26	Ballard. ....	4735.4	3. 67536
5 05 56	185 05 35	Grover's Cliff .....	8144.8	3. 91088
71 47 35	251 46 17	Ballard. ....	2780.0	3. 44405
11 22 15	191 21 23	Grover's Cliff .....	8880.6	3. 94844
68 16 00	248 14 12	Ballard. ....	3947.2	3. 59629
18 20 18	198 20 01	Nahant .....	1808.7	3. 25737
98 20 14	278 18 54	Little Nahant. ....	2743.1	3. 43824

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Crusoe House, flagstaff.	° / '' 42 26 10.65	328.6	° / '' 70 58 07.58	173.3
South Boston Point.	42 20 13.02	401.7	71 01 33.45	765.8
Castle Island.	42 20 19.26	594.5	71 00 45.65	1045.0
Nahant 2. 1860.	42 25 04.80	148.1	70 54 18.33	419.1
Winthrop Head.	42 22 04.07	125.6	70 58 06.04	138.2
Winthrop Head 2. 1877.	42 22 04.36	134.5	70 58 08.25	188.8
Tuft's College.	42 24 26.84	828.2	71 07 13.85	316.7
Ten Hill Farm, flag.	42 23 50.88	1569.8	71 05 15.26	349.0
Ten Hill Farm 2. 1860.	42 23 50.48	1557.6	71 05 15.44	353.1
Governor's Island 2. 1860.	42 21 09.10	280.8	71 00 42.86	980.9
Governor's Island 3. 1877.	42 21 08.84	272.8	71 00 41.12	941.1
East Boston.	42 22 53.13	1639.9	71 02 11.74	268.5
East Boston Point, flag.	42 21 58.24	1796.9	71 01 44.75	1023.9
East Boston Iron Works, chimney.	42 22 55.76	1720.4	71 01 48.44	1108.1
East Boston Reservoir.	42 22 52.76	1627.9	71 02 09.84	225.1
East Boston Reservoir 2. 1877.	42 22 52.56	1621.8	71 02 09.91	226.7
East Boston Elevator.	42 21 47.59	1468.4	71 02 15.51	354.9
East Boston Dry Dock, post.	42 21 44.76	1381.1	71 01 54.81	1254.2
East Boston ship-yard, east wharf post.	42 21 50.12	1546.5	71 01 41.59	951.7
East Boston, brick church, dark spire.	42 22 26.77	826.0	71 02 21.89	500.8
East Boston, granite church, dark spire.	42 22 16.06	495.5	71 02 28.44	650.7
Long wharf.	42 21 37.65	1162.0	71 02 53.75	1229.7
Long wharf 2, post. 1860.	42 21 36.45	1124.7	71 02 53.54	1225.2

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
0 16 06	180 16 05	Grover's Cliff . . . . .	5179.3	3.71427
52 52 37	232 50 06	Powderhorn.	6437.1	3.80869
126 53 40	306 52 07	Boston State House . . . . .	3937.1	3.59518
176 36 10	356 35 58	Powderhorn.	7160.8	3.85496
117 06 13	297 04 08	Boston State House . . . . .	4766.1	3.67816
167 41 31	347 40 46	Powderhorn.	7119.0	3.85242
0 11 37	180 11 36	Nantasket . . . . .	12623.2	4.10117
79 54 21	259 49 16	Powderhorn.	10538.5	4.02278
125 46 32	305 44 00	Powderhorn . . . . .	6369.4	3.80410
223 01 26	43 03 59	Nahant 2.	7630.4	3.88255
59 09 16	239 06 18	Blind Asylum . . . . .	7055.7	3.84854
125 56 30	305 53 59	Powderhorn 2.	6322.1	3.80086
275 16 38	95 20 15	Powderhorn . . . . .	7391.8	3.86875
319 40 15	139 42 32	Boston State House.	7171.8	3.85563
264 44 49	84 47 06	Powderhorn . . . . .	4667.9	3.66912
336 08 53	156 09 50	Boston State House.	4766.2	3.67817
336 02 33	156 03 30	Boston State House . . . . .	4756.6	3.67730
112 30 50	192 29 30	Tuft's College.	2931.3	3.46706
52 45 12	232 43 58	Blind Asylum . . . . .	3163.3	3.50014
163 43 45	343 42 58	Powderhorn.	5643.8	3.75157
53 18 13	233 16 58	Blind Asylum . . . . .	3190.4	3.50384
163 20 40	343 19 52	Powderhorn 2.	5659.9	3.75281
298 13 01	118 16 10	Deer Island . . . . .	7292.4	3.86287
6 02 02	186 01 46	Dorchester Heights.	5265.0	3.72140
315 40 50	135 41 34	Governor's Island . . . . .	2153.1	3.33307
336 06 12	156 06 52	Castle Island.	3340.2	3.52377
177 48 15	357 48 13	Powderhorn . . . . .	2128.2	3.32801
260 33 37	80 36 05	Grover's Cliff.	5096.6	3.70728
112 46 26	292 44 21	Ten Hill Farm 2 . . . . .	4603.4	3.66308
190 24 22	10 24 34	Powderhorn.	2256.5	3.35344
327 35 18	147 36 18	Governor's Island 3 . . . . .	3790.7	3.57872
5 52 42	185 52 27	Blind Asylum.	5134.0	3.71046
264 44 59	84 47 46	Winthrop Head 2 . . . . .	5681.5	3.75446
7 17 54	187 17 42	Blind Asylum.	3128.1	3.49528
350 11 57	170 12 11	South Boston Point . . . . .	2872.6	3.45828
16 06 58	196 06 32	Blind Asylum.	3138.7	3.49675
356 26 17	176 26 22	South Boston Point . . . . .	3001.9	3.47739
20 15 25	200 14 50	Blind Asylum.	3390.3	3.53024
192 44 50	12 45 10	Powderhorn . . . . .	3097.6	3.49103
198 58 51	18 58 59	East Boston Reservoir.	847.7	2.92826
193 57 33	13 57 58	Powderhorn . . . . .	3453.6	3.53827
200 35 15	20 35 28	East Boston Reservoir.	1209.3	3.08255
197 17 16	17 17 58	Powderhorn . . . . .	4751.5	3.67683
286 21 06	106 22 37	Governor's Island.	3213.4	3.50697
197 06 04	17 06 45	Powderhorn . . . . .	4785.5	3.67993
350 15 36	170 15 50	Blind Asylum.	2799.1	3.44702

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Neptune House, flagstaff.	° ' " 42 25 43.48	1341.5	° ' " 70 58 46.76	1068.9
Naval Hospital.	42 23 22.58	696.7	71 02 55.94	1279.6
Cushman's house, cupola.	42 24 59.35	1831.2	71 00 44.60	1019.7
Nahant Hotel, cupola.	42 25 09.20	283.9	70 54 19.84	453.6
Stone powder-house.	42 24 00.40	12.3	71 07 00.17	3.9
Grain mill, near turnpike, west chimney.	42 24 05.18	159.8	71 05 51.68	1181.8
Brick factory, near Mystic River, cupola.	42 24 32.76	1010.8	71 05 27.07	619.0
Tall chimney, north side of Mystic River.	42 24 36.17	1116.1	71 05 21.94	501.7
Chelsea church.	42 24 32.98	1017.5	71 00 26.28	600.8
Chelsea bridge.	42 22 56.55	1744.8	71 02 55.67	1273.5
Chelsea, dark spire, cross.	42 23 40.47	1248.7	71 01 54.68	1250.6
Chelsea, white spire, martin-hole windows.	42 23 24.55	757.5	71 02 19.91	455.6
Chelsea, white spire, with clock.	42 23 27.33	843.3	71 02 18.18	415.8
Chelsea, white spire, three tiers of windows.	42 23 36.20	1117.0	71 02 16.13	368.9
Chelsea, tall dark spire.	42 23 30.56	942.9	71 02 16.90	386.6
Chelsea, brown tower.	42 23 28.98	894.2	71 01 46.40	1061.3
Edgeworth Mills, round chimney.	42 25 01.38	42.6	71 04 30.87	705.8
Malden church, tall spire.	42 25 38.84	1198.3	71 04 01.56	35.6
Malden, yellow spire.	42 25 38.75	1195.6	71 04 01.44	32.9
Malden Bridge, yellow house chimney, at toll-gate.	42 23 34.58	1066.9	71 04 09.58	219.1
Malden Bridge.	42 23 11.41	352.1	71 04 13.50	308.8
Medford, Unitarian church.	42 25 13.97	431.0	71 06 56.23	1285.5
Medford, tall square chimney, near bridge.	42 24 52.20	1610.6	71 06 31.54	721.1

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
348 38 43	168 39 09	Grover's Cliff .....	4427. 5	3. 64616
54 16 33	234 14 28	Powderhorn. .	5218. 6	3. 71755
323 12 37	143 14 08	Governor's Island 3 .....	5152. 3	3. 71200
354 59 41	174 59 57	Blind Asylum.	6056. 8	3. 78224
201 05 59	21 06 48	Ballard .....	4571. 0	3. 66001
309 51 38	129 53 23	Grover's Cliff.	4646. 8	3. 66715
50 18 35	230 13 00	Dorchester Heights .....	14758. 4	4. 16904
79 08 42	259 03 37	Powderhorn.	10529. 1	4. 02239
268 53 55	88 57 23	Powderhorn .....	7048. 7	3. 84811
12 31 59	192 31 17	Corey.	6543. 6	3. 81582
270 08 13	90 10 55	Powderhorn .....	5481. 1	3. 73887
298 40 39	118 41 03	Ten Hill Farm 2.	944. 8	2. 97534
279 58 15	100 00 40	Powderhorn .....	4993. 8	3. 69843
85 43 56	265 42 44	Tuft's College.	2448. 7	3. 38894
281 25 17	101 27 39	Powderhorn .....	4898. 0	3. 69002
83 35 40	263 34 24	Tuft's College.	2575. 0	3. 41080
66 00 00	245 59 02	Powderhorn .....	2146. 1	3. 33165
19 38 22	199 36 55	Dorchester Heights.	8830. 2	3. 94597
179 32 09	359 32 09	Naval Hospital .....	803. 4	2. 90492
276 42 49	96 43 20	East Boston Reservoir 2.	1054. 2	3. 02293
93 52 08	273 49 52	Ten Hill Farm 2 .....	4601. 7	3. 66292
101 07 14	281 03 39	Tuft's College.	7438. 4	3. 87148
101 17 10	281 15 12	Ten Hill Farm 2 .....	4093. 8	3. 61213
105 59 02	281 55 44	Tuft's College.	6991. 7	3. 84458
100 00 36	279 58 36	Ten Hill Farm 2 .....	4116. 9	3. 61457
349 50 57	169 51 03	East Boston Reservoir.	1083. 6	3. 03488
96 09 07	276 07 06	Ten Hill Farm 2 .....	4124. 9	3. 61541
353 52 27	173 52 31	East Boston Reservoir.	1348. 2	3. 12974
352 07 33	172 07 38	East Boston Reservoir .....	1177. 7	3. 07105
104 22 14	284 18 54	Tuft's College.	7009. 9	3. 84571
25 36 51	205 36 41	East Boston Reservoir .....	1239. 8	3. 09334
173 21 32	353 21 28	Powderhorn.	1109. 1	3. 04497
295 41 53	115 43 40	Powderhorn .....	4031. 9	3. 60551
74 03 28	254 01 38	Tuft's College.	3876. 1	3. 58839
314 25 49	134 27 16	Powderhorn .....	4149. 0	3. 61794
30 18 36	210 15 54	Corey.	10914. 7	4. 03801
26 51 52	206 51 02	Ten Hill Farm 2 .....	3744. 7	3. 57342
63 15 04	243 12 54	Tuft's College.	4927. 0	3. 69258
183 22 12	3 22 20	Waite 1 .....	4520. 5	3. 65519
253 32 07	73 33 40	Powderhorn.	3280. 9	3. 51599
243 06 02	63 07 38	Powderhorn 2 .....	3627. 1	3. 55956
281 36 35	101 37 58	East Boston Reservoir 2.	2886. 6	3. 46038
287 03 16	107 06 41	Powderhorn .....	7277. 3	3. 86197
9 53 45	189 53 01	Corey.	8788. 2	3. 94390
282 53 30	102 56 38	Powderhorn .....	6558. 1	3. 81678
51 02 48	231 02 19	Tuft's College.	1244. 3	3. 09492

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Winnisimett, church with clock.	42 23 27.35	843.9	71 02 18.18	415.8
Somerville, church on hill.	42 23 12.18	375.8	71 05 52.37	1197.8
Somerville, red church, 1860.	42 23 11.98	369.6	71 05 52.46	1200.0
Somerville church, near Malden Bridge.	42 23 07.43	229.3	71 04 36.63	837.9
Mount Auburn.	42 22 10.94	337.6	71 08 40.37	923.7
Cambridge, Baptist church.	42 22 34.42	1061.9	71 07 07.71	176.4
Cambridge, Unitarian church.	42 22 28.70	885.5	71 07 10.78	246.6
Cambridge, gas works chimney.	42 22 24.35	751.3	71 07 36.78	841.5
Cambridgeport, Universalist church.	42 21 47.52	1466.2	71 06 00.88	20.1
Cambridgeport, observatory dome.	42 21 19.06	588.1	71 06 35.85	820.5
Cambridgeport, redoubt, flagstaff.	42 21 23.89	737.1	71 06 17.21	393.9
Cambridgeport, flagstaff near engine-house.	42 21 45.58	1406.4	71 05 15.64	357.9
East Cambridge court-house, cupola.	42 22 11.95	368.7	71 04 48.56	1111.1
East Cambridge, church near court-house.	42 22 11.46	353.5	71 04 50.78	1161.9
West Cambridge, tall spire with clock.	42 24 55.63	1716.6	71 09 15.82	361.8
Graves.	42 21 53.66	1655.7	70 52 12.61	288.5
Great Brewster.	42 20 01.96	60.5	70 53 45.18	1034.3
Great Brewster 2. 1860.	42 20 01.68	51.8	70 53 45.22	1035.3
Point Shirley foundry chimney.	42 21 31.80	981.2	70 58 20.22	462.7
Battery wharf.	42 22 01.32	40.8	71 02 59.22	1355.0
Guide Post, west end of mill-dam.	42 20 55.63	1716.4	71 05 51.00	1167.2
Belle Isle.	42 22 57.30	1767.9	70 59 56.35	1289.0
Navy-yard, battery near flagstaff.	42 22 23.97	739.6	71 03 06.32	144.6

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
154 17 08	334 16 01	Waite 1 .....	5256.8	3.72072
207 26 36	27 26 54	Powderhorn.	1298.4	3.11341
322 18 52	142 21 04	Dorchester Heights .....	7357.3	3.86672
31 14 29	211 13 02	Corey.	5730.1	3.75816
215 28 48	35 29 13	Ten Hill Farm 2 .....	1458.8	3.16400
253 30 26	73 33 08	Powderhorn.	5735.0	3.75853
334 02 24	154 03 45	Dorchester Heights .....	6313.8	3.80029
44 43 16	224 40 57	Corey.	6687.3	3.82525
249 22 13	69 26 48	Powderhorn .....	9978.8	3.99908
280 52 45	100 56 00	Boston State House.	6742.5	3.82882
248 52 47	68 56 20	Powderhorn .....	7739.8	3.88873
306 48 18	126 51 21	Dorchester Heights.	7771.6	3.89051
247 51 56	67 55 31	Powderhorn .....	7870.3	3.89599
305 26 41	125 29 46	Dorchester Heights.	7706.5	3.88786
9 38 39	189 38 22	Corey .....	3473.2	3.54073
187 53 52	7 54 07	Tuft's College.	3815.8	3.58158
101 12 49	281 11 02	Mount Auburn .....	3720.1	3.57056
233 21 10	53 23 58	Powderhorn.	7094.1	3.85090
54 30 43	234 29 45	Corey .....	2427.6	3.38517
171 28 10	351 27 44	Tuft's College.	5859.1	3.76783
57 02 27	237 01 16	Corey .....	2864.3	3.45702
113 54 54	293 53 18	Mount Auburn.	3583.5	3.55431
59 42 43	239 40 51	Corey .....	4415.4	3.64497
151 29 10	331 27 50	Tuft's College.	5663.2	3.75306
55 33 41	235 31 31	Corey .....	5374.8	3.73036
89 40 36	269 38 00	Mount Auburn.	5304.2	3.72462
189 40 48	9 41 29	Waite 1 .....	7179.6	3.85610
229 28 28	49 30 29	Powderhorn.	5378.5	3.73066
278 45 50	98 50 49	Powderhorn .....	10269.7	4.01156
348 14 01	168 14 51	Corey.	8265.5	3.91727
77 31 26	257 27 51	Deer Island .....	7463.5	3.87294
154 01 54	334 00 29	Nahant.	6559.5	3.81687
13 45 10	193 44 46	Nantasket .....	3375.5	3.52834
109 31 15	289 28 43	Deer Island.	5483.8	3.73908
123 59 32	303 54 05	Powderhorn .....	13427.0	4.12798
175 22 23	355 22 01	Nahant 2.	9383.4	3.97236
65 02 36	244 59 44	Dorchester Heights .....	6456.5	3.81000
134 15 15	314 12 52	Powderhorn.	6762.4	3.83010
201 59 27	22 00 12	Powderhorn .....	4104.8	3.61329
297 00 24	117 01 59	Governor's Island.	3601.2	3.55645
223 07 36	43 10 17	Powderhorn .....	7995.2	3.90283
289 48 56	109 51 07	Dorchester Heights.	4747.4	3.67646
63 16 21	243 13 43	Boston State House .....	6013.3	3.77911
128 10 07	308 08 49	Powderhorn.	3364.7	3.52694
208 40 14	28 41 04	Powderhorn .....	3541.9	3.54924
304 41 40	124 43 19	Governor's Island.	4100.0	3.61278



## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Bird Island.	42 21 22.80	703.4	71 01 15.97	365.5
Bird Island Beacon.	42 21 18.06	557.2	71 01 15.96	365.3
Navy-yard chimney.	42 22 30.04	926.9	71 03 09.16	209.6
Apple Island, flag.	42 21 31.55	973.5	70 59 32.43	742.1
Bluff Head, flag.	42 22 03.82	117.9	70 58 04.53	103.6
Lewis' wharf, cupola.	42 21 47.44	1463.8	71 03 00.02	0.5
Faneuil Hall.	42 21 36.38	1122.4	71 03 23.70	542.4
Bunker Hill Monument.	42 22 35.05	1081.4	71 03 40.56	927.9
Bunker Hill, Catholic church, cross.	42 22 53.34	1645.7	71 04 00.70	16.0
Green Island, flag.	42 21 11.17	344.6	70 53 33.01	755.5
Green Island 2. 1860.	42 21 11.14	343.7	70 53 33.02	755.7
McLean's Asylum, north dome.	42 22 37.26	1149.7	71 04 54.68	1250.9
Watertown, United States arsenal, flag.	42 21 42.72	1318.1	71 09 45.97	1051.9
Cushing's (J. P.) house, skylight.	42 22 48.57	1498.6	71 10 10.24	234.2
Breed's Island.	42 23 28.04	865.2	71 00 30.28	692.6
State-street block.	42 21 33.64	1038.0	71 03 08.13	186.0
Prospect Somerville.	42 22 54.62	1685.3	71 05 37.88	866.6
Waverly House.	42 22 17.56	541.8	71 03 46.42	1062.1
Fitchburg Depot.	42 22 00.36	11.1	71 03 41.64	952.8
Lowell Round House.	42 22 09.74	300.5	71 04 23.39	535.2
Lowell Draw, flagstaff.	42 22 05.14	158.6	71 04 08.40	192.2
Lowell Depot, flagstaff.	42 21 53.81	1660.3	71 03 47.12	1078.2
Organ Factory.	42 21 44.45	1371.5	71 04 58.17	1331.1

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
93 24 16	273 22 32	Boston State House .....	3555. 2	3. 55086
155 24 18	335 23 40	East Boston.	3065. 6	3. 48651
11 16 52	191 16 40	South Boston Point .....	2046. 3	3. 31096
38 46 46	218 45 54	Blind Asylum.	2810. 7	3. 44882
122 48 05	302 45 20	Tuft's College .....	6656. 7	8. 82326
130 41 06	310 39 41	Ten Hill Farm 2.	3808. 4	3. 58074
288 34 24	108 35 46	Deer Island .....	2932. 2	3. 46719
57 05 29	237 03 25	Dorchester Heights.	5003. 3	3. 69926
323 51 53	143 54 24	Nantasket .....	8713. 4	3. 94019
59 08 37	239 05 34	Dorchester Heights.	7237. 4	3. 85958
200 10 00	20 10 46	Powderhorn .....	4511. 5	3. 65432
290 30 07	110 31 42	Governor's Island.	3445. 2	3. 53722
204 37 00	24 38 02	Powderhorn .....	5033. 7	3. 70189
282 55 34	102 57 25	Governor's Island.	3867. 1	3. 58738
221 54 21	41 55 34	Powderhorn .....	3716. 8	3. 57017
302 46 31	122 48 33	Governor's Island.	4941. 4	3. 69385
123 09 36	303 07 26	Tuft's College .....	5276. 8	3. 72237
270 23 39	90 24 54	East Boston Reservoir.	2536. 5	3. 40424
11 17 25	191 16 53	Nantasket .....	5521. 2	3. 74203
86 49 02	266 46 22	Deer Island.	5455. 3	3. 73682
11 17 26	191 16 54	Nantasket .....	5520. 3	3. 74196
115 10 34	295 04 57	Powderhorn.	12609. 6	4. 10070
191 39 48	11 40 26	Waite 1 .....	6413. 6	3. 80710
237 08 18	57 10 21	Powderhorn.	4973. 5	3. 69666
247 57 29	68 02 48	Powderhorn .....	11693. 9	4. 06796
287 14 53	107 19 43	Dorchester Heights.	10309. 3	4. 01323
258 18 34	78 24 10	Powderhorn .....	11635. 6	4. 06579
324 54 20	144 55 46	Corey.	5097. 4	3. 70735
308 27 30	128 29 06	Winthrop Head 2 .....	4150. 0	3. 61805
121 04 34	301 03 39	Powderhorn.	2183. 5	3. 33915
282 48 12	102 49 51	Governor's Island 3 .....	3450. 0	3. 53782
343 11 42	163 12 06	Blind Asylum.	2791. 4	3. 44582
247 18 24	67 20 56	Powderhorn 2 .....	5598. 1	3. 74804
256 52 16	76 54 05	Naval Hospital.	3803. 4	3. 58017
209 55 13	29 55 47	Naval Hospital .....	2314. 9	3. 36454
293 57 00	113 58 01	East Boston Elevator.	2276. 5	3. 35726
213 10 52	33 12 06	Powderhorn 2 .....	4579. 2	3. 66079
281 18 00	101 18 58	East Boston Elevator.	2009. 6	3. 30312
224 19 13	44 20 55	Powderhorn 2 .....	4953. 6	3. 69492
302 53 11	122 54 02	State Street Block.	2051. 0	3. 31197
232 42 17	52 42 31	Waverly House .....	632. 1	2. 80076
283 31 40	103 31 58	Fitchburg Depot.	630. 1	2. 79943
275 13 09	95 14 11	East Boston Elevator .....	2104. 8	3. 32322
304 53 26	124 53 52	State Street Block.	1088. 1	3. 03665
238 06 08	58 06 56	Waverly House .....	1933. 3	3. 28630
254 19 55	74 20 47	Fitchburg Depot.	1819. 0	3. 25982

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Nealy's house.	42 21 22.37	690.2	71 06 27.13	620.9
Otter street.	42 21 21.48	662.8	71 04 24.90	569.9
Standard Sugar Refinery.	42 20 44.00	1357.6	71 03 15.58	356.6
South Boston sea-wall.	42 21 18.40	567.7	71 02 43.48	995.1
Point Curve.	42 21 14.02	432.6	71 02 56.28	1288.0
Center.	42 21 09.74	300.5	71 02 46.38	1061.5
Two-story house, smoke-pipe.	42 20 56.31	1737.5	71 05 52.96	1212.2
Powers & Melville's elevator, southwest gable.	42 22 59.03	1821.5	71 04 40.01	915.3
Coal shed, flagstaff.	42 23 06.56	202.4	71 02 39.20	896.7
Octagonal building.	42 21 37.37	1153.0	71 04 19.02	435.3
Shed, upper gable.	42 21 57.42	1771.7	71 04 11.87	271.6
Iron smoke-stack.	42 23 14.06	433.8	71 02 26.10	597.0
Glass Works, east gable of main building.	42 22 22.65	698.9	71 04 41.86	957.8
New England Glass Company's chimney.	42 22 21.35	658.8	71 04 40.31	922.3
Peck's chimney.	42 22 51.09	1576.4	71 03 03.64	83.3
Fitchburg Round House, flagstaff.	42 22 23.43	722.9	71 04 10.02	229.3
Round building, ventilator.	42 20 50.28	1551.4	71 03 27.19	622.4
Round brick building, iron rod.	42 23 14.81	457.0	71 04 29.82	682.4
Brick factory.	42 23 45.12	1392.2	71 04 12.89	294.8
Marine Hospital, flagstaff.	42 23 21.22	654.8	71 02 43.70	999.6
Winslow's factory, corner.	42 23 02.22	685.0	71 03 53.96	1234.4
Holmes' factory.	42 22 45.76	1412.0	71 03 29.36	671.7
Crossing, signal pole.	42 22 27.27	841.4	71 04 15.52	355.1

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
201 35 37	21 36 10	Prospect Somerville .....	3061. 2	3. 48589
251 28 54	71 29 54	Organ Factory.	2146. 9	3. 33182
90 34 20	270 32 58	Nealy's House .....	2797. 6	3. 44679
181 20 39	1 20 40	Lowell Round House.	1489. 8	3. 17314
186 21 28	6 21 33	State Street Block .....	1541. 1	3. 18782
319 23 35	139 24 04	Blind Asylum.	1502. 2	3. 17674
215 23 57	35 24 16	East Boston Elevator .....	1104. 8	3. 04330
276 00 32	96 01 54	Governor's Island 3.	2815. 8	3. 44960
155 51 41	335 51 33	State Street Block .....	663. 2	2. 82161
245 12 19	65 12 28	South Boston sea-wall.	322. 4	2. 50846
120 16 50	300 16 43	Point Curve .....	262. 1	2. 41849
193 56 28	13 56 30	South Boston sea-wall.	275. 5	2. 44011
135 47 35	315 47 12	Nealy's House .....	1121. 6	3. 04985
220 09 43	40 10 20	Organ Factory.	1944. 0	3. 28870
316 13 35	136 14 11	Waverly House .....	1771. 8	3. 24841
345 56 58	165 57 09	Lowell Round House.	1567. 6	3. 19524
302 48 49	122 49 09	East Boston Reservoir 2 .....	797. 5	2. 90175
142 13 40	322 13 29	Naval Hospital.	625. 5	2. 79625
103 42 42	283 42 16	Organ Factory .....	922. 4	2. 96492
174 17 53	354 17 50	Lowell Round House.	1003. 8	3. 00166
69 19 23	249 18 52	Organ Factory .....	1132. 8	3. 05415
145 16 59	325 16 51	Lowell Round House.	462. 6	2. 66516
330 49 39	150 49 50	East Boston Reservoir 2 .....	760. 0	2. 88082
51 23 24	231 23 04	Chelsea Bridge.	865. 8	2. 93740
277 03 24	97 04 01	Waverly House .....	1278. 0	3. 10652
296 30 27	116 31 08	Fitchburg Depot.	1540. 1	3. 18755
54 13 31	234 11 15	Corey .....	5696. 1	3. 75558
230 21 08	50 23 02	Powderhorn.	4998. 7	3. 69886
215 49 48	35 50 36	Powderhorn 2 .....	2796. 5	3. 44661
190 15 36	10 15 41	Naval Hospital.	987. 7	2. 99462
288 33 03	108 33 19	Waverly House .....	569. 1	2. 75517
35 53 55	215 53 46	Lowell Round House.	521. 3	2. 71708
198 03 40	18 03 53	State Street Block .....	1407. 5	3. 14844
261 24 53	81 26 45	Governor's Island 3.	3843. 7	3. 58475
246 56 18	66 58 04	Powderhorn 2 .....	3921. 3	3. 59343
282 05 40	102 07 14	East Boston Reservoir 2.	3273. 6	3. 51502
259 26 14	79 27 49	Powderhorn 2 .....	3276. 2	3. 51537
299 57 14	119 58 37	East Boston Reservoir 2.	3247. 3	3. 51152
221 26 38	41 27 13	Powderhorn 2 .....	1784. 3	3. 25146
318 50 05	138 50 28	East Boston Reservoir 2.	1174. 6	3. 06990
235 23 09	55 24 31	Powderhorn 2 .....	3387. 5	3. 52988
277 07 37	97 08 47	East Boston Reservoir 2.	2399. 1	3. 38005
213 55 07	33 55 29	Naval Hospital .....	1369. 5	3. 13656
222 27 37	42 28 43	Powderhorn 2.	3296. 3	3. 51803
294 13 42	114 14 02	Waverly House .....	729. 8	2. 86319
18 22 53	198 22 48	Lowell Round House.	569. 8	2. 75573

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Gambrel roof, northeast gable.	42 22 18.38	567.1	71 03 26.45	605.2
Tudor cupola.	42 22 14.98	462.2	71 03 39.81	910.9
Gray's wharf, long brick building, northeast corner.	42 22 09.48	292.5	71 03 16.38	374.8
Prince street draw-tender's house, pole.	42 22 07.79	240.4	71 03 35.91	821.7
Draw, northwest corner, iron crane.	42 22 05.92	182.7	71 03 56.41	1290.7
Car-shed, northeast ventilator.	42 22 09.94	306.7	71 04 00.51	11.7
One-story red building, southwest end.	42 22 07.93	244.7	71 04 17.38	397.7
National dock building, southeast corner.	42 22 02.92	90.1	71 02 33.56	767.9
Long wharf building, lightning rod.	42 21 37.08	1144.1	71 02 57.46	1314.9
Cunard wharf, flagstaff.	42 21 50.08	1545.8	71 02 26.90	615.5
Cunard wharf, flagstaff, 1877.	42 21 49.98	1542.2	71 02 27.98	640.3
Cunard wharf, pole, 1860.	42 21 50.37	1554.2	71 02 29.04	664.5
Fawn Beacon.	42 21 17.58	542.4	70 56 32.87	752.5
Deer Island Beacon.	42 20 23.44	723.2	70 57 18.41	421.4
Deer Island Hospital, cupola.	42 21 12.39	382.3	70 57 53.15	1216.4
Deer Island flag, 1860.	42 21 01.24	38.3	70 57 30.95	708.4
Lincoln's wharf, post.	42 21 57.72	1781.0	71 02 58.15	1330.6
Eastern avenue wharf, post.	42 21 50.10	1545.9	71 02 56.18	1285.6
Loring's machine shop, wharf.	42 20 31.60	975.0	71 02 02.70	61.8
Foster's wharf, post.	42 21 21.15	652.6	71 03 01.36	31.1
South Bay Tripod.	42 19 31.09	959.3	71 03 46.58	1066.6
Prentice's coal wharf, post.	42 21 08.76	270.3	71 03 11.58	265.0
Sailor's Home, cupola.	42 21 19.10	589.3	71 03 08.40	192.2

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
32 00 48	212 00 38	Fitchburg Depot.....	655. 4	2. 81649
86 49 48	266 49 35	Waverly House.	457. 9	2. 66076
5 16 56	185 16 55	Fitchburg Depot.....	452. 8	2. 65594
117 41 06	297 41 02	Waverly House.	171. 1	2. 23314
64 02 03	244 01 46	Fitchburg Depot.....	642. 7	2. 80803
109 54 20	289 54 00	Waverly House.	731. 3	2. 86409
29 45 18	209 45 14	Fitchburg Depot.....	263. 9	2. 42143
141 22 23	321 22 16	Waverly House.	385. 7	2. 58620
212 26 57	32 27 04	Waverly House .....	425. 6	2. 62898
296 51 29	116 51 39	Fitchburg Depot.	379. 0	2. 57869
233 54 38	53 54 47	Waverly House .....	398. 8	2. 60072
304 22 06	124 22 19	Fitchburg Depot.	523. 4	2. 71887
247 14 31	67 14 52	Waverly House .....	767. 9	2. 88528
285 55 18	105 55 42	Fitchburg Depot.	850. 6	2. 92970
9 23 06	189 22 59	South Boston sea-wall .....	1392. 4	3. 14376
41 11 24	221 11 01	State Street Block.	1201. 0	3. 07954
330 58 35	150 58 44	South Boston sea-wall .....	659. 1	2. 81894
66 27 19	246 27 12	State Street Block.	266. 3	2. 42540
297 33 28	117 34 41	Governor's Island .....	2784. 7	3. 44478
3 35 13	183 35 07	Dorchester Heights.	3297. 2	3. 51815
20 00 27	200 00 17	South Boston sea-wall .....	1036. 9	3. 01574
61 13 56	241 13 29	State Street Block.	1048. 0	3. 02035
337 02 08	157 02 45	South Boston Point .....	3262. 1	3. 51350
1 34 18	181 34 15	Blind Asylum.	3189. 6	3. 50374
203 41 31	23 43 02	Nahant 2 .....	7657. 0	3. 88406
331 33 28	151 34 57	Nantasket.	6382. 0	3. 80496
106 47 40	286 45 25	Governor's Island .....	4796. 2	3. 68090
166 08 48	346 08 40	Deer Island.	1202. 4	3. 08006
134 14 04	314 11 23	Powderhorn .....	7624. 1	3. 88219
214 24 06	34 26 31	Nahant 2.	8693. 2	3. 93918
133 29 12	313 26 16	Powderhorn .....	8228. 9	3. 91534
210 21 58	30 24 08	Nahant 2.	8711. 6	3. 94010
201 06 28	21 07 13	Powderhorn .....	4199. 4	3. 62319
350 22 35	170 22 52	Blind Asylum.	3464. 0	3. 53958
199 27 40	19 28 23	Powderhorn .....	4404. 3	3. 64388
350 28 12	170 28 28	Blind Asylum.	3224. 6	3. 50848
42 19 59	222 19 39	Blind Asylum .....	1025. 2	3. 01082
237 39 07	57 40 01	Governor's Island 2.	2163. 0	3. 33506
276 40 45	96 42 18	Governor's Island 2 .....	3191. 8	3. 50403
344 04 37	164 04 56	Blind Asylum.	2378. 0	3. 37622
178 23 53	358 23 50	Boston State House .....	3658. 0	3. 56324
236 40 43	56 41 33	Blind Asylum.	2019. 5	3. 30525
269 48 30	89 50 10	Governor's Island 2 .....	3403. 7	3. 53195
306 00 41	126 01 27	Loring's machine shop.	1949. 4	3. 28989
275 16 49	95 18 27	Governor's Island 2 .....	3345. 2	3. 52442
339 54 17	159 54 41	Blind Asylum.	2367. 7	3. 37432

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Boylston School, cupola.	42 21 21.51	663.7	71 03 09.02	206.4
Fort Hill wharf, post.	42 21 15.74	485.7	71 03 05.16	118.1
Central wharf, cupola.	42 21 32.54	1004.0	71 03 05.21	119.2
India wharf, cupola.	42 21 29.10	897.9	71 02 59.70	1366.2
India wharf, post.	42 21 28.04	865.2	71 02 59.09	1352.2
Grand Junction wharf, shears.	42 21 47.39	1462.2	71 02 22.93	524.7
Bay State Iron Works, north gable.	42 20 24.77	764.3	71 02 22.31	510.7
Bay State Steam-Engine Works, wharf post.	42 21 45.52	1404.5	71 02 09.69	221.7
Adams' School, flagstaff.	42 21 57.86	1785.2	71 01 59.08	1351.9
Hog Island tripod.	42 23 30.16	930.6	71 00 39.69	907.8
Gas works, north end of Boston, chimney.	42 22 01.90	58.6	71 03 28.38	649.4
Gas Works, near Malden Bridge, chimney.	42 23 18.75	578.5	71 04 29.70	679.4
Miller's River, head of, church.	42 22 44.08	1360.1	71 05 48.79	1116.2
Carpet-cleaning factory, ventilator.	42 21 16.62	512.8	71 04 39.93	913.9
Mill-dam, yellow house, chimney.	42 20 56.22	1734.7	71 05 51.67	1182.7
Mill-dam, regatta house, flagstaff.	42 21 04.89	150.9	71 05 19.01	435.1
Planing mill, chimney.	42 22 16.17	498.9	71 07 17.17	392.9
Varnish factory, chimney.	42 21 49.54	1528.6	71 07 06.33	144.9
Riverside Press, chimney.	42 21 46.03	1420.2	71 06 57.05	1305.5
Charles River tripod.	42 21 09.41	290.3	71 07 00.28	6.4
Small red house on marsh, chimney.	42 24 45.88	1415.6	71 06 07.72	176.5
Cloverden.	42 22 47.54	1466.9	71 07 18.42	421.4
Cloverden Observatory, astronomical latitude station (zenith telescope), 1855 and 1864.	42 22 46.29	1428.3	71 07 17.60	402.6

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
340 11 10	160 11 34	Blind Asylum .....	2442. 5	3. 38783
314 00 08	134 01 12	South Boston Point.	3041. 7	3. 48311
273 35 38	93 37 14	Governor's Island 2 .....	3263. 2	3. 51364
313 36 22	133 37 04	Loring's machine shop.	1974. 7	3. 29549
322 43 43	142 44 25	Loring's machine shop .....	2362. 9	3. 37344
344 19 19	164 19 41	Blind Asylum.	2740. 4	3. 43781
319 55 36	139 56 34	South Boston Point .....	3067. 1	3. 48673
346 21 24	166 21 42	Blind Asylum.	2605. 4	3. 41587
319 44 02	139 45 00	South Boston Point .....	3033. 1	3. 48189
346 29 22	166 29 40	Blind Asylum.	2570. 4	3. 41000
338 44 39	158 45 12	South Boston Point .....	3124. 4	3. 49476
4 12 02	184 11 55	Blind Asylum.	3104. 9	3. 49205
153 44 39	333 44 08	State Street Block .....	2369. 7	3. 37470
239 34 19	59 35 27	Governor's Island 3.	2685. 7	3. 42906
343 47 22	163 47 46	South Boston Point .....	2972. 1	3. 47306
9 54 10	189 53 54	Blind Asylum.	3084. 6	3. 48920
349 43 14	169 43 31	South Boston Point .....	3287. 4	3. 51685
12 44 48	192 44 25	Blind Asylum.	3505. 7	3. 54477
60 46 02	240 45 01	East Boston Reservoir.....	2363. 0	3. 37346
122 46 44	302 45 55	Powderhorn.	1967. 3	3. 29387
66 28 25	246 25 21	Corey .....	6836. 0	3. 83480
92 15 59	272 12 29	Mount Auburn.	7144. 1	3. 85395
133 06 00	313 05 29	Ten Hill Farm 2 .....	1433. 2	3. 15630
284 03 28	104 05 02	East Boston Reservoir.	3298. 5	3. 51832
245 18 43	65 21 23	Powderhorn .....	5959. 4	3. 77520
75 25 20	255 23 24	Mount Auburn.	4056. 4	3. 60814
73 56 29	253 54 13	Corey .....	4818. 3	3. 68289
106 57 54	286 55 12	Mount Auburn.	5751. 9	3. 75981
120 51 39	300 49 45	Mount Auburn .....	4496. 7	3. 65289
163 52 18	343 51 23	Tuft's College.	6765. 5	3. 83030
75 25 22	255 23 32	Corey .....	3859. 8	3. 58657
113 52 40	293 50 24	Mount Auburn.	5038. 6	3. 70231
17 59 52	197 59 22	Corey .....	3334. 7	3. 52306
181 04 15	1 04 17	Tuft's College.	4032. 7	3. 60560
28 33 18	208 32 40	Corey .....	2675. 3	3. 42738
107 04 15	287 03 12	Mount Auburn.	2250. 8	3. 35234
33 37 59	213 37 15	Corey .....	2692. 3	3. 43012
173 34 21	355 34 10	Tuft's College.	4976. 8	3. 69695
129 39 54	309 38 47	Mount Auburn .....	2974. 9	3. 47347
177 05 02	357 04 53	Tuft's College.	6099. 7	3. 78531
325 01 36	145 02 11	Ten Hill Farm 2 .....	2086. 0	3. 31932
68 46 32	248 45 47	Tuft's College.	1622. 4	3. 21017
249 00 39	69 01 37	Somerville church, 1860 .....	2106. 2	3. 32350
107 30 10	287 29 53	Cambridge Observatory.	610. 7	2. 78582
154 01.1	334 01.1	Cloverden .....	42. 98	1. 63323



## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Agassiz Museum.	° / '' 42 22 44.52	1373.7	° / '' 71 06 56.04	1282.0
Gould's Transitory, 1865.	42 22 41.01	1265.4	71 06 57.87	1323.8
Boston, Hollis street church.	42 20 59.42	1833.3	71 03 53.15	1216.4
Boston, Hanover street brick church.	42 21 49.90	1539.6	71 03 17.44	399.1
Boston, St. Mary's church, north spire.	42 21 54.82	1691.5	71 03 29.69	679.4
Boston Neck, dark spire with clock.	42 20 26.77	826.0	71 04 25.27	578.5
Boston, Catholic cathedral, statue.	42 20 12.67	390.9	71 04 25.14	575.5
Boston, Berkley street, yellow spire.	42 20 44.13	1361.6	71 04 15.42	353.0
Boston jail, cupola.	42 21 43.26	1334.5	71 04 14.44	330.4
Boston, State prison, cupola.	42 22 28.23	871.0	71 04 08.84	202.2
Boston light-house (C. & G. S. & B.), 1834-'47.	42 19 40.74	1257.0	70 53 26.18	599.4
South Boston flats, A.	42 20 21.44	661.5	71 01 39.28	899.1
South Boston flats, B.	42 20 21.59	666.2	71 02 14.82	339.3
South Boston flats, C.	42 20 15.97	492.8	71 02 35.44	811.3
South Boston flats, D.	42 20 30.32	935.5	71 03 06.10	134.6
South Boston flats, E.	42 20 34.38	1060.7	71 03 15.65	358.2
South Boston Reservoir.	42 19 58.48	1804.4	71 02 46.56	1066.0
South Boston, dark spire with turrets, cross.	42 20 31.87	983.3	71 03 24.44	559.5
West Boston bridge, pole on draw.	42 21 41.49	1280.2	71 04 26.12	597.7
Charlestown, brick church, cross.	42 22 21.96	677.6	71 03 48.32	1105.5
Outer Brewster.	42 20 29.40	907.2	70 52 41.16	942.1
Outer Brewster 2. 1860.	2 20 29.33	905.0	70 52 41.21	943.3
Brighton, east church.	42 20 57.83	1784.3	71 09 13.03	298.3

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
239 46 25	59 47 08	Somerville church, 1860.....	1683. 3	3. 22616
104 11 43	284 11 11	Cambridge Observatory.....	1128. 9	3. 05264
201 09	21 09	Agassiz Museum.....	116. 2	2. 06534
266 26 51	86 29 02	Governor's Island.....	4451. 1	3. 64847
314 19 47	134 20 39	Dorchester Heights.....	2471. 9	3. 39393
289 28 50	109 30 37	Governor's Island.....	3845. 5	3. 58495
343 51 41	163 52 09	Dorchester Heights.....	3420. 1	3. 53404
209 08 56	29 10 02	Powderhorn 2.....	4584. 2	3. 66126
277 28 18	97 29 08	East Boston Elevator.....	1711. 9	3. 23349
332 43 11	152 43 37	South Bay Tripod.....	1933. 0	3. 28623
118 51 24	298 48 32	Mount Auburn.....	6664. 4	3. 82376
273 51 19	93 52 35	Blind Asylum.....	2576. 3	3. 41100
325 27 19	145 27 45	South Bay Tripod.....	1557. 4	3. 19241
343 40 01	163 40 20	South Bay Tripod.....	2348. 4	3. 37078
86 21 40	266 19 07	Corey.....	5201. 6	3. 71614
67 33 03	247 30 30	Corey.....	5641. 1	3. 75136
98 00 50	277 57 51	Mount Auburn.....	6144. 7	3. 78850
130 52 14	310 50 09	Tuft's College.....	5594. 7	3. 74778
149 01 56	329 01 11	Ten Hill Farm 2.....	2959. 9	3. 47128
125 10 34	305 04 53	Powderhorn.....	14152. 5	4. 150832
173 12 42	353 12 07	Nahant.....	10068. 1	4. 002949
273 07 09	93 07 45	Castle Island.....	1229. 4	3. 08969
223 37 47	43 38 28	Governor's Island.....	1998. 4	3. 30068
133 37 36	313 36 31	Boston State House.....	3041. 9	3. 48314
236 40 03	56 41 08	Governor's Island.....	2624. 2	3. 41900
142 42 44	322 41 53	Boston State House.....	2855. 8	3. 45573
238 46 04	58 47 22	Governor's Island.....	3115. 9	3. 49359
150 39 04	330 38 34	Boston State House.....	2098. 4	3. 32188
250 47 13	70 48 52	Governor's Island.....	3564. 7	3. 55202
154 34 42	334 34 18	Boston State House.....	1886. 5	3. 27566
253 42 12	73 43 58	Governor's Island.....	3734. 7	3. 57226
58 23 19	238 22 39	South Bay Tripod.....	1613. 4	3. 20775
188 52 41	8 53 06	East Boston Reservoir.....	5443. 0	3. 73584
252 43 28	72 45 17	Governor's Island 2.....	3872. 8	3. 58802
15 06 56	195 06 41	South Bay Tripod.....	1942. 5	3. 28837
66 59 46	246 57 20	Corey.....	5373. 7	3. 73027
98 54 04	278 51 13	Mount Auburn.....	5888. 4	3. 77000
219 59 52	40 01 10	Powderhorn.....	4138. 0	3. 61679
247 07 33	67 08 39	East Boston Reservoir.....	2445. 1	3. 38830
28 48 29	208 47 22	Nantasket.....	4708. 4	3. 67287
98 28 05	278 24 50	Deer Island.....	6706. 4	3. 82649
117 51 07	297 44 56	Powderhorn.....	14246. 9	4. 15372
165 21 30	345 20 25	Nahant 2.....	8785. 0	3. 94374
240 12 54	60 17 51	Powderhorn.....	11620. 9	4. 06524
280 25 27	100 29 54	Dorchester Heights.....	9244. 0	3. 96586

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Brighton, west church, with clock.	42 20 56.25	1735.5	71 09 20.29	464.4
North Brighton, dark spire.	42 21 13.69	422.4	71 08 12.35	282.6
Moon Head 1.	42 18 22.20	684.9	70 59 23.06	528.1
Moon Head 2. 1860.	42 18 22.04	680.0	70 59 23.13	529.8
Weeks' house, chimney.	42 20 21.21	654.4	70 53 49.02	1122.2
Weeks' barn, center chimney.	42 20 23.48	724.5	70 53 52.86	1210.1
Kimbal's house, center chimney.	42 20 19.12	590.0	20 53 26.75	612.4
Machine-shop, tall chimney on ridge pole.	42 20 28.60	882.5	71 03 59.10	1352.9
Gas Works, ventilator.	42 20 50.28	1551.4	71 03 27.18	622.1
Fulton Wire Works, south chimney.	42 20 08.04	248.1	71 03 29.56	676.7
Lawrence School, cupola.	42 20 28.78	888.0	71 03 12.88	294.8
Railroad tripod.	42 20 52.37	1615.9	21 02 57.82	1323.5
James and Pope's timber dock, post.	42 20 32.51	1003.1	71 02 39.68	908.3
Fort Independence, flagstaff, 1861.	42 20 18.90	583.2	71 00 44.92	1028.3
George's Island.	42 19 11.16	344.3	70 55 42.32	969.1
Barrel Beacon.	42 19 22.27	687.1	70 55 09.18	210.2
Brookline, Dr. Pierce's church.	42 19 38.18	1178.0	71 07 52.48	1201.5
Gallop Island, flag.	42 19 37.30	1150.9	70 56 21.48	491.7
Gallop Island 2. 1860.	42 19 37.97	1171.5	70 56 23.16	530.3
Lovel's Island, pole.	42 19 48.60	1499.4	70 55 50.36	1152.9
Nix's Mate.	42 19 53.55	1652.2	70 56 40.94	937.2
Sargent's observatory.	42 18 42.75	1319.0	71 05 41.40	948.1
Roxbury, Jamaica Plains, tall church spire.	42 18 36.44	1124.3	71 06 59.36	1359.4

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
240 24 36	60 29 39	Powderhorn .....	11789.6	4.07150
291 32 25	111 33 18	Corey.	1921.8	3.28371
160 03 03	340 02 44	Mount Auburn .....	1879.4	3.27402
349 25 19	169 25 26	Corey.	1265.3	3.10221
307 35 18	27 36 33	Deer Island .....	5538.9	3.74342
271 37 45	91 41 09	Nantasket.	6939.7	3.84134
162 09 04	342 07 24	Powderhorn .....	11107.8	4.04563
271 35 23	91 38 47	Nantasket.	6941.3	3.84144
10 26 44	190 26 23	Nantasket .....	3938.2	3.59530
64 21 41	244 17 56	Moon Head 2.	8488.3	3.92882
9 01 20	189 01 02	Nantasket .....	3992.4	3.60123
63 40 25	243 36 43	Moon Head 2.	8440.0	3.92634
17 49 11	197 48 35	Nantasket .....	4000.3	3.60209
121 05 47	301 00 06	Powderhorn.	13494.3	4.13015
288 37 06	108 38 04	Blind Asylum .....	2083.1	3.31872
350 49 29	170 49 37	South Bay Tripod.	1797.5	3.25468
261 12 23	81 14 14	Governor's Island 2 .....	3805.2	3.58038
10 18 00	190 17 47	South Bay Tripod.	2483.6	3.39508
271 21 22	91 22 00	Blind Asylum .....	1298.3	3.11338
18 52 08	198 51 57	South Bay Tripod.	1204.8	3.08090
250 03 59	70 05 40	Governor's Island 2 .....	3652.2	3.56256
23 25 56	203 25 33	South Bay Tripod.	1939.9	3.28778
260 29 57	80 31 28	Governor's Island 2 .....	3131.8	3.49579
337 46 47	157 47 04	Blind Asylum.	1511.0	3.17926
271 53 30	91 53 55	Loring's machine shop .....	847.0	2.92790
348 45 22	168 45 27	Blind Asylum.	801.3	2.90380
80 43 26	260 42 53	South Boston Point .....	1125.8	3.05145
157 44 51	337 43 54	East Boston Reservoir.	5129.7	3.71009
312 17 29	132 18 24	Nantasket .....	2542.8	3.40531
21 10 17	201 09 20	Great Qu ncy.	5364.3	3.72951
237 30 32	57 31 29	Great Brewster .....	2280.0	3.35793
331 21 57	151 22 50	Nantasket.	2340.4	3.36929
172 33 44	352 33 37	Corey .....	1717.7	3.23495
225 03 19	45 07 22	Powderhorn.	11647.4	4.06623
148 27 02	328 26 15	Deer Island .....	3040.9	3.48300
257 59 01	78 00 46	Great Brewster.	3658.6	3.56331
312 01 34	132 02 57	Nantasket .....	3791.1	3.57877
60 24 12	240 22 11	Moon Head 2.	4740.8	3.67585
132 14 23	314 13 15	Deer Island .....	3214.9	3.50717
261 48 27	81 49 51	Great Brewster.	2895.6	3.46174
266 17 44	86 19 42	Great Brewster .....	4032.3	3.60555
313 07 28	133 09 03	Nantasket.	4416.0	3.64503
136 39 04	316 37 29	Corey .....	4695.4	3.67167
239 36 20	59 38 25	Dorchester Heights.	4923.1	3.69224
158 15 58	338 15 16	Corey .....	3884.5	3.58933
263 46 33	83 47 25	Sargent's Observatory.	1796.1	3.25434

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / //		° / //	
Roxbury, laboratory, chimney.	42 19 24.52	756.5	71 05 52.98	1213.1
Roxbury, Dr. Putnam's church.	42 19 47.81	1475.1	71 05 24.96	571.4
Roxbury, new Unitarian church.	42 19 42.11	1299.2	71 04 51.72	1184.1
Roxbury Oil Works, chimney.	42 19 55.40	1709.4	71 03 55.14	1262.4
Spectacle Island, flag.	42 19 38.90	1200.3	70 59 16.66	381.4
Squantum.	42 18 13.89	428.7	71 00 41.57	952.1
Thompson's Island, flag.	42 19 14.60	450.5	71 00 16.12	369.2
Thompson's Island, pole near farm school.	42 19 07.56	233.3	71 00 26.01	595.6
Thompson's Island 2. 1860.	42 19 07.88	243.1	71 00 25.65	587.4
Long Island, south end, flag.	42 18 39.52	1219.4	70 58 37.16	851.0
Long Island, south end 2. 1860.	42 18 39.60	1221.9	70 58 36.88	844.6
Long Island Hotel, cupola.	42 19 27.40	845.4	70 57 53.39	1222.5
Farm school-house, southeast gable.	42 19 05.26	162.3	71 00 27.55	630.9
Fort Warren, west gable of house.	42 19 13.10	404.2	70 55 42.40	970.9
Flagstaff, corner Dorchester street and turnpike.	42 19 47.62	1469.3	71 03 26.50	606.7
Suffolk Cordage Factory, ball.	42 19 38.04	1173.7	71 04 20.24	463.4
Point Allerton, flag.	42 18 37.12	1145.3	70 52 59.36	1359.4
Point Allerton beacon, 1860.	42 18 47.08	1452.6	70 53 00.29	6.6
Commercial Point wharf, flag.	42 18 00.28	8.6	71 02 38.24	875.9
Dorchester, Dr. Codman's church.	42 17 26.85	828.4	71 04 18.00	412.4
Dorchester, church with clock.	42 18 29.60	913.3	71 03 45.81	1049.2
Summer-house on hill.	42 18 09.13	281.8	71 04 35.65	816.6
North Pettick Island.	42 18 06.28	193.8	70 55 47.57	1089.6

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
212 30 40	32 33 22	Powderhorn .....	10253. 4	4. 01087
255 04 54	75 07 07	Dorchester Heights.	4669. 0	3. 66922
111 20 56	291 19 10	Corey .....	3864. 5	3. 58709
211 33 50	31 36 14	Powderhorn.	9304. 2	3. 96868
109 57 24	289 55 16	Corey .....	4639. 0	3. 66642
258 02 18	78 03 49	Dorchester Heights.	3178. 2	3. 50218
259 11 56	79 12 51	Blind Asylum .....	1917. 6	3. 28275
345 20 51	165 20 57	South Bay Tripod.	775. 3	2. 88946
99 26 00	279 23 46	Dorchester Heights .....	4623. 3	3. 66501
145 38 57	235 38 02	Governor's Island.	3341. 4	3. 52393
142 14 36	322 13 19	Dorchester Heights .....	4275. 0	3. 63094
269 36 06	89 40 23	Nantasket.	8735. 3	3. 94128
115 13 04	295 11 30	Dorchester Heights .....	3537. 4	3. 54868
171 30 00	351 29 45	Governor's Island.	3547. 4	3. 54991
12 08 47	192 08 37	Squantum .....	1693. 5	3. 22879
120 06 31	300 05 04	Dorchester Heights.	3437. 6	3. 53626
167 49 45	347 48 47	Powderhorn .....	9368. 7	3. 97168
280 51 22	100 55 28	Nantasket.	8522. 8	3. 93058
199 05 54	19 06 39	Deer Island .....	4629. 0	3. 66549
277 05 50	97 08 43	Nantasket.	5931. 0	3. 77313
156 01 13	335 59 02	Powderhorn .....	10979. 4	4. 04058
206 26 25	26 29 19	Nahant 2.	13276. 4	4. 12308
147 28 37	327 25 56	Powderhorn .....	10149. 9	4. 00646
205 16 44	25 19 09	Nahant 2.	11514. 9	4. 06126
168 11 30	348 10 33	Powderhorn .....	9438. 9	3. 97492
280 16 09	100 20 16	Nantasket.	8551. 1	3. 93202
313 15 05	133 16 00	Nantasket .....	2584. 8	3. 41242
72 42 46	252 40 17	Moon Head 2.	5295. 0	3. 72387
42 03 44	222 03 30	South Bay Tripod.	686. 4	2. 83660
243 58 08	63 58 44	Blind Asylum.	1366. 5	3. 13560
249 59 19	70 00 31	Blind Asylum .....	2616. 3	3. 41769
285 31 53	105 32 16	South Bay Tripod.	800. 2	2. 90318
70 21 32	250 20 38	Nantasket .....	1965. 9	3. 29357
158 10 17	338 09 46	Great Brewster.	2820. 1	3. 45026
85 00 04	264 55 46	Moon Head 2. ....	8802. 0	3. 94458
128 53 46	308 47 48	Powderhorn.	15623. 9	4. 19379
180 48 11	0 48 13	Dorchester Heights .....	3800. 1	3. 57979
261 03 06	81 04 25	Squantum.	2705. 1	3. 43219
205 48 41	25 49 50	Dorchester Heights .....	5367. 0	3. 72973
253 39 28	73 41 54	Squantum.	5165. 6	3. 71312
208 55 54	28 56 41	Dorchester Heights .....	3308. 0	3. 51956
276 32 06	96 34 10	Squantum.	4247. 5	3. 62813
217 51 19	37 52 40	Dorchester Heights .....	4467. 0	3. 65002
268 24 26	88 27 04	Squantum.	5363. 6	3. 72946
261 44 14	81 45 13	Nantasket .....	2022. 2	3. 30582
156 19 52	336 18 42	Deer Island.	5896. 0	3. 77056

## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
North Pettick Island 2. 1860.	° / '' 42 18 06.32	195.0	° / '' 70 55 47.73	1093.3
South Pettick Island.	42 17 23.82	735.0	70 56 51.66	1183.5
Rainsford Island, flagstaff. 1846.	42 18 46.83	1444.9	70 57 07.41	169.7
Rainsford Island flag, 1860.	42 18 46.91	1447.4	70 57 07.12	16.3
Hull, Oregon House, cupola.	42 18 12.14	374.6	70 54 47.44	1086.6
Hull, Steamboat Hotel, cupola.	42 18 16.26	501.7	70 55 08.29	189.9
Strawberry Hill, barn.	42 17 22.52	694.8	70 52 49.47	1133.4
Neponset church.	42 17 11.62	358.5	71 07 52.87	1211.3
Hangman's Ledge Beacon.	42 17 44.75	1380.8	70 57 39.22	898.4
Forbes.	42 15 27.87	859.9	71 01 38.94	892.5
Crow Point.	42 15 41.98	1295.3	70 53 46.47	1065.1
Sagamore Head.	42 16 24.46	754.7	70 51 50.04	1146.6
Turkey Hill.	42 14 25.68	792.4	70 51 14.22	326.0
Eaton's Hill, flag.	42 15 44.08	1360.0	70 59 53.43	1224.5
Parker's Hill.	42 13 45.60	1406.9	70 46 49.45	1133.8
Paine's Hill observatory.	42 14 01.56	48.2	70 59 42.96	985.1
Thayer's Hill, yellow house, chimney.	42 13 51.49	1588.7	70 58 10.55	241.9
Bunkin Island, flag.	42 16 51.86	1600.1	70 54 02.85	65.3
Black Rock.	42 16 08.56	264.1	70 49 28.42	651.3
Grape Island, flag.	42 16 07.28	224.4	70 55 27.21	623.6
Baker's Hill.	42 14 35.94	1108.9	70 54 28.47	652.7
Hingham, church with clock.	42 14 34.32	1058.9	70 53 29.43	674.7
Hingham, old church.	42 14 26.68	884.9	70 53 14.96	343.0

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
95 38 01	275 35 36	Moon Head 2 -----	4957.5	3.69526
143 01 03	322 56 58	Powderhorn.	13848.4	4.14140
117 22 37	297 20 55	Moon Head 2 -----	3905.4	3.59167
193 50 21	13 52 04	Nahant 2.	14651.1	4.16587
172 35 15	352 34 59	Deer Island -----	4183.6	3.62155
284 04 03	104 05 55	Nantasket.	3948.2	3.59640
76 10 22	256 08 50	Moon Head 2 -----	3208.2	3.50626
146 24 19	326 21 07	Powderhorn.	11774.7	4.07095
138 15 57	318 11 11	Powderhorn -----	14585.8	4.16393
182 59 34	2 59 54	Nahant 2.	12750.0	4.10551
91 46 25	271 43 34	Moon Head 2 -----	5839.7	3.76639
139 21 34	319 17 02	Powderhorn.	14175.6	4.15154
74 23 16	254 20 23	Great Quincy -----	6124.2	3.78705
128 17 29	308 16 28	Nantasket.	2648.3	3.42297
184 11 19	4 11 30	Dorchester Heights -----	5315.3	3.72553
237 24 42	57 26 10	Squantum.	3569.3	3.55258
122 13 42	302 10 22	Dorchester Heights -----	8029.7	3.90470
181 46 36	1 46 42	Deer Island.	6066.7	3.78295
171 16 48	351 16 10	Dorchester Heights -----	8602.4	3.93462
242 42 23	62 47 18	Nantasket.	11308.4	4.05340
52 06 28	232 03 11	White's Hill -----	8510.8	3.92997
107 33 39	287 31 24	Great Quincy.	4817.0	3.68278
91 08 35	271 05 02	Great Quincy -----	7261.6	3.86102
134 56 45	314 55 04	Nantasket.	4859.7	3.68660
74 18 26	254 13 27	White's Hill -----	10604.0	4.02547
149 02 02	328 59 57	Nantasket.	8277.9	3.91792
238 28 21	58 32 05	Nantasket -----	8953.9	3.95201
342 11 42	162 12 32	White's Hill.	5561.1	3.74516
57 38 54	237 35 47	Prospect Hingham -----	7542.9	3.87754
102 09 14	282 07 12	Scituate.	4263.4	3.62976
218 09 50	38 11 35	Great Quincy -----	5788.6	3.76257
325 35 44	145 36 27	White's Hill.	2583.7	3.41224
196 42 21	16 43 04	Great Quincy -----	5075.2	3.70545
266 22 55	86 28 31	Scituate.	11471.5	4.05962
80 31 42	260 29 38	Great Quincy -----	4275.2	3.63096
171 15 41	351 15 29	Nantasket.	2617.0	3.41780
93 29 04	273 23 56	Great Quincy -----	10525.0	4.02222
120 25 58	300 22 42	Nantasket.	7751.0	3.88936
201 10 25	21 11 10	Nantasket -----	4249.1	3.62830
263 54 08	83 56 34	Sagamore Head.	5005.0	3.69940
133 52 31	314 50 44	Great Quincy -----	5035.6	3.70205
181 36 04	1 36 10	Nantasket.	6782.7	3.83140
125 23 58	305 21 32	Great Quincy -----	6112.7	3.78623
213 49 45	33 50 52	Sagamore Head.	4090.9	3.61182
124 57 22	304 54 46	Great Quincy -----	6484.1	3.81185
162 17 38	342 17 17	Crow Point.	2373.6	3.37541



## BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Hingham, Old Colony House, cupola.	42 14 51.75	1596.7	70 52 22.62	518.5
Hingham, Great Plain church.	42 12 38.35	1183.2	70 53 04.50	103.2
Milton, old church.	42 15 12.35	381.0	71 04 50.38	1154.8
Milton Mills, tall church spire.	42 16 26.49	817.3	71 04 07.96	182.4
Wellington Hill, flag.	42 16 59.24	1827.8	71 05 44.08	1010.0
Atlantic House, chimney.	42 16 03.02	93.3	70 50 53.05	1215.7
Rockland House, cupola.	42 15 56.90	1755.5	70 51 10.05	230.3
Pig Rock Beacon.	42 16 44.04	1358.8	70 56 22.65	519.0
Quincy, Bent's Point church.	42 14 45.75	1411.6	70 58 31.97	732.9
Quincy, stone church.	42 15 04.25	131.1	71 00 12.98	297.5
Quincy, black top church.	42 15 00.66	20.4	70 59 49.90	1143.8
Minot's Ledge light-house, 1847-'77.	42 16 11.16	344.3	70 45 34.71	795.4
Cohasset church.	42 14 35.63	1099.3	70 48 14.02	321.4
Weymouth Great Hill, flag.	42 14 59.38	1832.1	70 56 33.50	767.8
North Weymouth church.	42 13 46.46	1433.4	70 56 42.94	984.6
East Weymouth church.	42 12 50.40	1555.0	70 55 31.08	712.9
King Oak Hill, pole.	42 13 38.94	1201.4	70 56 25.32	580.6

## FROM CAPE COD BAY TO BOSTON BAY.

Monk's Hill (C. & G. S. & B.).	41 57 39.108	1206.7	70 43 23.398	538.8
• Carolina Hill.	42 06 58.520	1805.4	70 43 52.853	1214.2
Prospect Hingham (C. & G. S. & B.).	42 11 34.686	1070.2	70 51 27.166	623.3
Sprague (C. & G. S. & B.).	42 00 17.896	552.2	70 58 00.109	2.5

## BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
128 52 51	308 51 55	Crow Point .....	2469. 3	3. 39257
194 37 39	14 38 01	Sagamore Head.	2956. 2	3. 47073
236 08 45	56 10 55	Scituate .....	5336. 1	3. 72722
311 19 53	131 20 58	Prospect Hingham.	2973. 9	3. 47332
156 05 43	336 03 34	Corey .....	10836. 3	4. 03488
198 55 06	18 56 37	Dorchester Heights.	9494. 9	3. 97749
197 28 34	17 29 36	Dorchester Heights .....	7017. 3	3. 84617
234 57 19	54 59 38	Squantum.	5774. 3	3. 76150
154 25 49	334 24 16	Corey .....	7325. 5	3. 86484
217 09 14	37 11 21	Dorchester Heights.	7132. 3	3. 85323
95 23 14	275 19 03	Great Quincy .....	8604. 4	3. 93472
130 47 57	310 45 38	Nantasket.	6267. 6	3. 79710
330 11 22	150 12 15	Scituate .....	3635. 6	3. 56058
1 57 01	181 56 58	Turkey Hill.	2816. 4	3. 44970
168 51 04	348 50 18	Deer Island .....	8090. 0	3. 90795
224 45 27	44 46 49	Nantasket.	3983. 3	3. 60024
221 39 51	41 42 40	Nantasket .....	8674. 0	3. 93822
301 08 21	121 13 07	Prospect Hingham.	11387. 5	4. 05643
233 48 32	53 52 29	Nantasket .....	10012. 0	4. 00052
298 09 03	118 14 56	Prospect Hingham.	13683. 3	4. 13619
233 51 57	53 53 47	Great Quincy .....	4625. 6	3. 66517
337 44 08	157 44 55	White's Hill.	4273. 8	3. 63081
58 34 57	238 32 05	Scituate .....	6892. 1	3. 838352
107 44 55	287 39 03	Nantasket.	12637. 7	4. 101667
247 40 10	67 41 27	Ocean House .....	2822. 2	3. 45059
300 37 12	120 39 09	Cat Hill.	4629. 0	3. 66549
206 44 50	26 46 20	Nantasket .....	6783. 6	3. 83146
311 55 34	131 59 00	Prospect Hingham.	9447. 1	3. 97530
58 02 11	238 00 53	White's Hill .....	3145. 9	3. 49775
173 45 40	353 45 24	Great Quincy.	5045. 8	3. 70293
189 11 15	9 12 03	Nantasket .....	10167. 6	4. 00722
292 38 11	112 40 55	Prospect Hingham.	6063. 9	3. 78275
64 59 51	244 58 21	White's Hill .....	3390. 7	3. 53029
169 43 06	349 42 38	Great Quincy.	5334. 0	3. 72705

## FROM CAPE COD BAY TO BOSTON BAY.

288 41 59. 6	108 47 17. 3	Manomet .....	11560. 9	4. 062992
130 53 24. 9	310 37 40. 4	Blue Hill.	42760. 3	4. 631041
357 44 58. 0	177 45 17. 7	Monk's Hill .....	17273. 1	4. 237371
108 43 33. 0	288 28 06. 8	Blue Hill.	33418. 6	4. 523988
309 12 12. 3	129 17 17. 2	Carolina Hill .....	13468. 5	4. 129319
95 50 00. 1	275 39 38. 4	Blue Hill.	21339. 0	4. 329175
283 33 45. 4	103 43 31. 8	Monk's Hill .....	20768. 8	4. 317410
152 03 25. 9	331 57 28. 8	Blue Hill.	26068. 1	4. 416109

## FROM CAPE COD BAY TO BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Gurnet.	° / '' 42 00 11.398	351.7	° / '' 70 36 06.055	139.4
Brant.	42 05 17.319	534.4	70 38 28.702	659.7
White.	42 07 05.938	183.2	70 41 24.595	565.0
Alden (Borden).	41 49 48.328	1491.1	70 57 02.790	64.4
Telegraph Hill (Borden).	42 06 53.638	1654.9	70 41 50.218	1153.6
Scituate light-house (C. & G. S. & B.), 1834-1849.	42 12 17.316	534.3	70 42 58.736	1347.4
Standish.	42 00 50.77	1566.4	70 40 58.21	1339.4
Standish monument.	42 00 50.24	1550.0	70 40 57.66	1326.7
Plymouth.	41 57 24.78	764.5	70 40 07.93	182.6
Plymouth Pier Head.	41 58 46.50	1434.6	70 39 13.38	308.0
Plymouth Court-House (Borden), 1835.	41 57 26.37	813.5	70 40 02.23	51.4
Plymouth National Monument.	41 57 36.69	1132.0	70 40 34.87	803.0
Plymouth (Gurnet) light-house (Borden), 1835.	42 00 12.10	373.3	70 36 04.33	99.6
Plymouth (Gurnet) light-house, 1848-1870.	42 00 12.30	379.5	70 36 04.03	92.7
North Plymouth Rope Works.	41 58 47.50	1465.5	70 41 20.16	464.1
Kingston.	41 58 53.29	1644.1	70 41 54.63	1257.6
Kingston spire.	41 59 36.08	1113.2	70 43 52.77	1214.6
East Duxbury belfry.	42 02 08.10	249.9	70 40 24.05	553.2
West Duxbury Unitarian steeple.	42 02 06.65	205.2	70 41 33.44	769.2
Duxbury, astronomical longitude station, transit, 1869-1870.	42 02 55.18	1702.5	70 40 10.96	252.1
Duxbury Pier light-house, 1877.	41 59 14.94	461.0	70 38 56.57	1302.2
Powder Point.	42 02 49.15	1516.4	70 39 10.75	247.2
Eel River steeple.	41 56 15.18	468.3	70 37 49.12	1131.6

## FROM CAPE COD BAY TO BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
65 01 23.1	244 56 30.6	Monk's Hill -----	11110.6	4.045737
139 31 49.6	319 26 36.9	Carolina Hill.	16522.3	4.218069
346 52 48.7	166 54 49.5	Manomet -----	18329.6	4.263152
25 38 52.9	205 35 35.6	Monk's Hill.	15679.0	4.195317
338 49 17.8	158 53 16.4	Manomet -----	22734.4	4.356683
8 53 29.3	188 52 09.7	Monk's Hill.	17700.8	4.247994
249 58 27.9	70 12 52.2	Manomet -----	31749.7	4.501739
232 21 54.6	52 31 01.8	Monk's Hill.	23827.8	4.377083
337 04 39.9	157 08 55.7	Manomet -----	22603.6	4.354178
7 08 55.9	187 07 53.5	Monk's Hill.	17242.9	4.236610
347 18 50.1	167 19 53.3	White -----	9847.4	3.993321
110 58 42.6	290 54 05.4	Scituate.	10129.5	4.005586
280 12 52	100 16 08	Gurnet -----	6831.7	3.83453
321 41 01	141 44 42	Manomet.	12266.5	4.08872
321 40 59	141 44 39	Manomet -----	12245.9	4.08799
29 38 55	209 37 18	Monk's Hill.	6784.7	3.83153
227 15 55	47 18 37	Gurnet -----	7578.4	3.87958
95 37 36	275 35 25	Monk's Hill.	4523.1	3.65544
318 08 22	138 10 53	Manomet -----	7777.5	3.89084
238 42 27	58 44 32	Gurnet.	5045.1	3.70287
297 43 29	117 46 32	Manomet -----	7134.8	3.85338
171 55 58	351 54 46	Telegraph Hill.	17677.5	4.24742
297 13 46	117 17 11	Manomet -----	7948.2	3.90027
91 07 04	271 05 11	Monk's Hill.	3881.8	3.58903
354 21 10	174 21 34	Manomet -----	8476.6	3.92822
65 00 30	244 55 36	Monk's Hill.	11155.8	4.04750
354 24 32	174 24 56	Manomet -----	8482.2	3.92851
64 59 38	244 54 44	Monk's Hill.	11164.0	4.04782
305 39 47	125 43 43	Manomet -----	9983.4	3.99928
250 16 20	70 19 50	Gurnet.	7679.4	3.88533
303 57 44	124 02 02	Manomet -----	10737.2	4.03089
253 15 01	73 18 54	Gurnet.	8377.4	3.92311
264 09 52	84 15 04	Gurnet -----	10796.7	4.03329
349 23 13	169 23 33	Monk's Hill.	3672.0	3.56490
330 25 04	150 28 22	Manomet -----	13811.5	4.14024
26 27 35	206 25 35	Monk's Hill.	9269.2	3.96704
324 52 26	144 56 30	Manomet -----	14628.8	4.16521
17 03 18	197 02 05	Monk's Hill.	8633.6	3.93619
334 10 20	154 13 29	Manomet -----	14957.9	4.17487
51 43 52	231 42 57	West Duxbury Unitarian steeple.	2416.6	3.38320
324 14 45	144 17 04	Manomet -----	8219.2	3.91483
64 19 24	244 16 26	Monk's Hill.	6818.0	3.83366
158 47 31	338 46 01	White -----	8499.4	3.92939
191 56 15	11 56 43	Brant.	4672.5	3.66955
198 01 36	18 02 45	Gurnet -----	7664.8	3.88450
108 37 14	288 33 31	Monk's Hill.	8123.3	3.90973

## FROM CAPE COD BAY TO BOSTON BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Webster's flagstaff.	° ' " 42 04 39. 21	1209. 8	° ' " 70 40 13. 77	316. 5
Webster's (Hon. Daniel) house, west chimney.	42 04 48. 26	1489. 0	70 40 47. 07	1081. 9
Lewis.	42 08 09. 45	291. 6	70 43 13. 69	314. 4
Hatch.	42 08 08. 48	261. 6	70 42 11. 36	260. 9
Third Cliff.	42 10 49. 78	1536. 0	70 43 01. 94	44. 5
Briggs.	42 10 02. 49	76. 8	70 44 57. 31	1315. 5
North Marshfield Unitarian spire.	42 08 30. 15	930. 2	70 44 29. 46	676. 5
Scituate Unitarian church.	42 12 00. 69	21. 3	70 45 22. 19	509. 0
Studley.	42 08 13. 49	416. 2	70 48 07. 38	168. 5
Bonney.	42 03 10. 50	324. 0	70 52 34. 01	782. 1
Coleman.	42 10 42. 14	1300. 2	70 43 38. 65	887. 0

## CAPE COD BAY AND PENINSULA.

Provincetown.	42 03 08. 452	260. 7	70 11 20. 533	472. 2
Scargo.	41 44 22. 481	693. 6	70 10 49. 824	1151. 3
Chatham (C. & G. S. & B.).	41 41 50. 705	1564. 3	69 58 48. 380	1118. 7
Mill Hill (C. & G. S. & B.).	41 46 34. 142	1053. 4	70 00 06. 967	160. 7
Griffin's Island.	41 56 14. 374	443. 4	70 04 06. 046	139. 3
Race Point light house, 1877.	42 03 44. 564	1374. 9	70 14 36. 989	850. 4
Long Point light-house, 1877.	42 01 59. 467	1834. 8	70 10 09. 008	207. 2
Wood End light-house, 1877.	42 01 16. 608	512. 4	70 11 38. 491	885. 7
Cape Cod (Highlands of Truro) light-house, 1877.	42 02 23. 165	714. 7	70 03 39. 833	916. 1
Billingsgate light-house, 1868.	41 52 18. 221	562. 1	70 04 09. 871	227. 6

## FROM CAPE COD BAY TO BOSTON BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
338 27 38	158 30 49	Manomet -----	17925.9	4. 25348
18 37 16	198 35 09	Monk's Hill.	13676.3	4. 13597
168 31 40	348 31 15	White -----	4334.8	3. 63697
328 55 09	148 56 14	Powder Point.	4290.9	3. 63255
182 34 05	2 34 15	Scituate light-house -----	7655.6	3. 88398
308 00 48	128 02 01	White.	3181.0	3. 50256
315 53 32	135 56 01	Brant -----	7352.4	3. 86643
330 53 39	150 54 10	White.	2208.5	3. 34410
3 07 15	183 07 07	Lewis -----	4954.6	3. 69501
342 03 27	162 04 32	White.	7259.1	3. 86088
241 07 54	61 09 11	Third Cliff. -----	3023.3	3. 48048
325 41 36	145 42 45	Lewis.	4222.2	3. 62554
167 21 18	347 20 59	Briggs -----	2920.1	3. 46540
204 59 33	25 00 32	Third Cliff.	4753.7	3. 67703
261 07 41	81 09 17	Scituate light-house -----	3330.9	3. 52256
329 01 24	149 04 04	White.	10604.5	4. 02549
143 33 42	323 31 28	Prospect Hingham -----	7717.7	3. 88749
208 23 25	28 25 16	Scituate Unitarian church.	7970.0	3. 90146
185 37 46	5 38 31	Prospect Hingham -----	15631.8	4. 19401
239 31 24	59 37 13	Carolina Hill.	13891.5	4. 14275
197 19 06	17 19 33	Scituate light-house -----	3076.0	3. 48798
135 34 38	315 33 28	Scituate Unitarian church.	3393.9	3. 53070

## CAPE COD BAY AND PENINSULA.

67 31 32.8	247 15 24.4	Manomet -----	36095.1	4. 557448
17 54 15.3	197 47 55.4	Shootflying.	42821.5	4. 631662
178 50 07.6	358 49 47.1	Provincetown -----	34746.5	4. 540911
66 35 20.7	246 28 41.5	Shootflying.	15119.3	4. 179530
105 45 02.0	285 37 01.9	Scargo -----	17321.8	4. 238592
75 04 18.8	254 51 15.5	Hyannis.	28226.4	4. 450655
74 45 44.4	254 38 36.3	Scargo -----	15396.6	4. 187426
153 13 22.7	333 05 52.7	Provincetown.	34380.9	4. 536317
141 59 15.2	321 54 24.5	Provincetown -----	16224.2	4. 210163
342 51 22.2	162 54 01.7	Mill Hill.	18731.8	4. 272579
62 37 00.1	242 23 03.0	Manomet -----	32465.0	4. 511415
11 38 05.1	191 33 56.3	Shootflying.	42747.2	4. 630907
71 34 23.9	251 17 27.8	Manomet -----	36893.3	4. 566947
20 59 38.6	200 52 31.0	Shootflying.	41361.8	4. 616599
72 33 29.5	252 17 33.4	Manomet -----	34527.5	4. 538165
18 52 17.5	198 46 09.7	Shootflying.	39416.5	4. 595678
74 19 09.7	253 57 53.2	Manomet -----	45668.2	4. 659614
31 12 18.1	211 00 50.8	Shootflying.	45974.5	4. 662517
32 12 30.4	212 08 03.8	Scargo -----	17340.0	4. 239050
332 08 25.9	152 11 07.9	Mill Hill.	12004.8	4. 079357

## CAPE COD BAY AND PENINSULA—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
German Hill.	° / '' 41 41 27.962	862.7	° / '' 70 12 35.978	832.0
Point Gammon.	41 37 04.965	153.2	70 15 39.322	910.3
Monomoy.	41 35 37.602	1160.0	69 59 03.358	77.8
Rock Point.	41 46 12.951	399.5	70 04 46.025	1063.1
Orleans 2. 1868.	41 47 32.585	1005.4	70 00 51.627	1191.9
Atwood.	41 45 11.393	351.6	70 04 24.315	561.7
Hamblin's Hill.	41 41 49.931	1540.4	70 24 13.644	315.5
Bourne's Hill (C. & G. S. & B.).	41 44 00.818	25.2	70 29 11.627	268.7
Small's Hill (Borden).	42 00 35.256	1087.8	70 02 10.298	237.0
Peaked Cliff.	41 48 31.383	968.1	70 32 25.060	578.5
Holmes.	41 55 26.564	819.5	70 32 39.017	899.0
Scorton Neck.	41 44 19.130	590.1	70 24 41.190	951.8
Mount Schaum.	41 45 25.096	774.2	70 30 49.984	1154.7
Scorton Hill.	41 43 17.257	532.4	70 23 41.434	957.7
Indian Brook.	41 51 30.36	936.7	70 00 23.41	539.9
Blackfish Creek.	41 54 28.86	890.4	70 01 04.80	110.6
Hamblin's Mound.	41 56 14.18	437.5	70 02 47.46	1093.2
Cambria.	41 59 14.88	459.1	70 00 45.13	1038.8
Highland.	42 01 41.33	1275.2	70 02 47.49	1092.4
Pamet.	42 00 14.91	460.0	70 04 52.68	1212.3
Stout.	42 04 09.52	293.8	70 07 32.83	754.7
Lombard Head.	41 55 51.66	1593.9	69 58 51.02	1175.4
Race.	42 04 50.41	1555.3	70 12 26.65	612.5

## CAPE COD BAY AND PENINSULA—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
50 48 53.8	230 45 00.7	Hyannis .....	10472.5	4.020052
267 49 25.5	87 58 36.0	Chatham .....	19150.7	4.282185
207 35 10.2	27 37 12.1	German Hill .....	9156.0	3.961704
249 15 22.7	69 26 34.7	Chatham .....	24996.8	4.397885
96 45 26.8	276 34 25.5	Point Gammon .....	23219.7	4.365856
181 43 24.1	1 43 34.1	Chatham .....	11515.9	4.061299
67 57 38.2	247 53 35.9	Scargo .....	9069.5	3.957585
264 10 55.2	84 14 01.1	Mill Hill .....	6478.3	3.811459
65 36 34.1	245 33 57.9	Rock Point .....	5944.5	3.774116
330 13 40.1	150 14 09.9	Mill Hill .....	2077.2	3.317471
246 44 03.6	66 46 55.0	Mill Hill .....	6469.6	3.810878
80 25 13.7	260 20 57.0	Scargo .....	9034.4	3.955902
312 14 51.6	132 18 42.3	Hyannis .....	10849.8	4.035423
255 42 43.2	75 51 38.1	Scargo .....	19167.8	4.282573
158 03 37.6	337 59 26.5	Manomet .....	23218.0	4.365825
263 08 42.4	83 28 04.2	Mill Hill .....	40583.2	4.608346
78 56 11.1	258 33 55.2	Manomet .....	46903.2	4.671202
353 44 10.1	173 45 32.5	Mill Hill .....	26105.9	4.416739
162 15 35.5	342 13 33.3	Manomet .....	13843.3	4.141240
310 23 26.8	130 31 09.8	Shootflying .....	21113.8	4.324567
95 30 15.8	275 28 22.8	Manomet .....	3914.5	3.592678
358 33 33.1	178 33 42.4	Peaked Cliff .....	12813.4	4.107665
144 36 32.7	324 29 21.2	Manomet .....	25737.7	4.410570
126 02 17.2	305 57 08.2	Peaked Cliff .....	13241.9	4.121950
283 23 55.2	103 28 00.8	Scorton Neck .....	8760.8	3.942544
159 06 04.8	339 05 01.4	Peaked Cliff .....	6152.4	3.789046
111 45 18.9	291 40 33.6	Mount Schaum .....	10659.6	4.027742
128 45 07.0	308 39 18.2	Peaked Cliff .....	15499.0	4.190304
47 40 05	227 33 07	Scargo .....	19580.6	4.291826
149 39 44	329 37 15	Griffin's Island .....	10154.8	4.006671
35 52 16	215 45 46	Scargo .....	23071.2	4.363070
127 56 42	307 54 41	Griffin's Island .....	5295.2	3.723886
26 55 23	206 50 01	Scargo .....	24616.6	4.391228
137 18 43	317 13 00	Provincetown .....	17401.7	4.240591
357 50 55	177 51 20	Mill Hill .....	23487.6	4.370839
116 17 58	296 10 53	Provincetown .....	16299.1	4.212164
102 52 48	282 47 05	Provincetown .....	12101.9	4.082854
10 10 23	190 09 31	Griffin's Island .....	10248.5	4.010659
121 00 07	300 55 47	Provincetown .....	10405.1	4.017248
227 11 31	47 12 55	Highland .....	3925.1	3.593847
304 50 27	124 53 38	Highland .....	7997.8	3.902968
341 59 52	162 02 10	Griffin's Island .....	15412.7	4.187879
50 21 46	230 20 17	Blackfish Creek .....	4003.6	3.60245
95 32 23	275 28 53	Griffin's Island .....	7291.6	3.86282
334 12 03	154 12 47	Provincetown .....	3493.9	3.54331
280 33 11	100 36 28	Stout .....	6871.0	3.83702



## CAPE COD BAY AND PENINSULA—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Truro Congregational spire.	° / '' 41 59 54.06	1667.9	° / '' 70 03 18.44	424.4
Long Point school-house.	42 01 21.71	669.8	70 10 55.15	1268.8
Long Point light-house, 1847.	42 01 59.12	1824.1	70 10 08.87	204.0
Race Point light-house, 1835-'47 (C. & G. S. & B.).	42 03 44.36	1368.7	70 14 36.98	850.2
Mayo's Beach light-house, 1877.	41 55 49.82	1537.2	70 02 05.66	130.4
Provincetown Methodist Center church.	42 03 12.55	387.2	70 11 05.52	126.9
Provincetown Methodist Centenary church.	42 02 52.44	1617.9	70 11 26.78	615.9
Provincetown Baptist church, belfry	42 03 27.45	847.0	70 10 39.74	913.7
Provincetown old Universalist church, belfry, 1835-'47 (C. & G. S. & B.).	42 02 51.02	1574.2	70 11 26.99	620.7
Provincetown new Universalist church, spire.	42 03 02.08	64.2	70 11 19.94	458.5
Provincetown Orthodox church, spire.	42 03 04.03	124.3	70 11 17.61	405.0
Provincetown Methodist church, belfry.	42 03 06.52	201.2	70 11 17.82	409.8
Provincetown school-house.	42 02 41.17	1270.2	70 11 36.90	848.6
Provincetown Academy.	42 03 09.78	301.8	70 11 14.50	333.4
Cape Cod (Highlands of Truro) light-house (C. and G. S. and B.), 1835-'47.	42 02 23.18	715.2	70 03 39.84	916.4
North Wellfleet Methodist belfry.	41 56 19.66	606.5	70 01 48.95	1127.6
North Wellfleet Congregational belfry.	41 56 09.64	297.4	70 01 16.48	379.7
South Wellfleet Congregational belfry.	41 54 32.07	989.5	69 59 07.10	163.6
South Wellfleet Methodist meeting-house.	41 54 24.54	757.1	69 59 07.72	177.9
Billingsgate light-house (C. & G. S. & B.). 1835-'47.	41 51 38.77	1196.1	70 04 16.72	384.8
Nauset Center light-house, 1846.	41 51 38.63	1191.8	69 57 05.42	125.0
Eastham Congregational spire.	41 50 28.28	872.5	69 58 54.33	1253.5
Nauset Harbor.	41 47 22.72	701.0	69 56 46.80	1080.6

## CAPE COD BAY AND PENINSULA—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
106 31 31	286 30 28	Pamet .....	2261.8	3.35446
192 08 24	12 08 45	Highland.	3385.7	3.52965
221 55 45	41 58 01	Stout .....	6961.3	3.842693
315 09 21	135 13 54	Griffin's Island.	13364.8	4.125962
221 42 59	41 44 43	Stout .....	5390.7	3.73164
142 23 51	322 23 03	Provincetown.	2700.2	3.43140
283 45 20	103 47 31	Provincetown .....	4650.7	3.66751
235 45 30	55 46 57	Race.	3623.8	3.55917
350 54 53	170 56 12	Mill Hill .....	17361.1	4.239578
29 44 47	209 38 57	Scargo.	24412.4	4.387610
67 33 07	247 16 49	Manomet .....	36462.5	4.561846
18 17 33	198 11 03	Shootflying.	43049.2	4.633965
68 10 02	247 53 58	Manomet .....	35775.7	4.553588
17 55 23	197 49 07	Shootflying.	42307.4	4.626416
253 10 38	73 12 43	Stout .....	4489.3	3.652174
325 49 18	145 53 41	Griffin's Island.	16144.3	4.208018
245 45 57	65 48 34	Stout .....	5904.0	3.771144
320 17 18	140 22 13	Griffin's Island.	15899.5	4.201383
248 15 14	68 17 46	Stout .....	5621.7	3.749869
321 30 48	141 35 38	Griffin's Island.	16061.2	4.205779
248 37 37	68 40 08	Stout .....	5549.1	3.744224
321 47 43	141 52 32	Griffin's Island.	16075.4	4.206162
249 23 08	69 25 39	Stout .....	5526.3	3.742436
321 57 04	142 01 53	Griffin's Island.	16138.6	4.207866
244 04 18	64 07 01	Stout .....	6239.0	3.795118
318 56 58	139 02 00	Griffin's Island.	15814.8	4.199064
250 05 53	70 08 21	Stout .....	5420.1	3.734005
322 23 05	142 27 52	Griffin's Island.	16171.3	4.208745
97 33 06	277 27 57	Provincetown .....	10686.3	4.028828
3 02 01	183 01 43	Griffin's Island.	11395.2	4.056720
343 25 10	163 25 39	Blackfish Creek .....	3566.5	3.55224
87 03 21	267 01 49	Griffin's Island.	3162.8	3.50007
355 03 18	175 03 26	Blackfish Creek .....	3120.7	3.49425
92 09 08	272 07 15	Griffin's Island.	3909.0	3.59207
87 55 18	267 53 59	Blackfish Creek .....	2714.2	3.43363
114 38 28	294 35 08	Griffin's Island.	7577.3	3.87951
92 50 20	272 49 02	Blackfish Creek .....	2701.5	3.43161
116 15 52	296 12 33	Griffin's Island.	7664.0	3.88446
328 27 18	148 30 05	Mill Hill .....	11024.9	4.042373
34 01 25	213 57 03	Scargo.	16233.9	4.210423
24 03 21	204 01 20	Mill Hill .....	10286.1	4.012249
54 48 55	234 39 46	Scargo.	23309.4	4.367531
55 43 46	235 35 49	Scargo .....	20007.6	4.301194
146 05 15	326 01 47	Griffin's Island.	12870.9	4.109610
146 49 16	326 46 52	Indian Brook .....	9130.2	3.96048
72 03 28	252 01 15	Mill Hill.	4858.7	3.68652

## CAPE COD BAY AND PENINSULA—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Station south of Nauset lights.	41 51 10.90	336.3	69 57 00.54	12.5
Eastham.	41 49 26.09	804.9	70 00 14.92	344.3
Orleans.	41 47 32.47	1002.2	70 00 51.46	1188.2
Brewster.	41 46 12.76	393.7	70 04 46.46	1073.1
Pleasant Bay.	41 44 34.89	1076.4	69 58 39.64	916.0
Nauset Beach.	41 44 05.66	174.6	69 55 34.32	793.1
Brewster Unitarian spire, 1846-'68.	41 45 43.24	1334.0	70 04 57.32	1324.1
Orleans Orthodox spire.	41 47 04.86	149.9	69 58 30.20	697.4
North Dennis.	41 44 42.24	1303.2	70 12 29.82	689.0
North Dennis, white spire, 1846-'68.	41 44 13.77	424.8	70 11 35.41	818.3
North Dennis, gray spire, 1846.	41 44 14.85	458.2	70 11 32.53	751.7
North Dennis 2. 1868.	41 43 29.20	900.9	70 12 04.70	108.6
Bass Hole.	41 42 49.98	1542.0	70 14 15.54	358.4
Monomoy light-house (C. & G. S. & B.). 1835-'46.	41 33 35.02	1080.4	69 59 40.76	944.5
Monomoy light-house, 1867-'80.	41 33 33.78	1042.1	69 59 39.02	904.2
Point Gammon light-house (C. & G. S. & B.). 1835-'47.	41 36 35.00	1079.8	70 16 00.19	4.4
East Scargo (Borden).	41 44 00.87	26.8	70 10 16.39	378.8
German Hill (Borden).	41 41 27.90	860.7	70 12 36.07	834.1
Barnstable.	41 41 48.82	1506.2	70 18 25.58	591.5
Barnstable, Unitarian spire.	41 42 02.46	75.9	70 17 57.67	1333.4
Barnstable light-house, 1846.	41 43 21.16	652.8	70 16 53.34	1232.9
Barnstable, west spire.	41 41 54.89	1693.4	70 23 03.28	75.8
Barnstable court-house (Borden), 1835.	41 42 06.02	185.7	70 18 17.64	407.8

## CAPE COD BAY AND PENINSULA—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
357 25 22	177 25 31	Nauset Harbor .....	7047.4	3.84803
26 45 49	206 43 45	Mill Hill.	9561.2	3.98051
358 00 57	178 01 02	Mill Hill .....	5308.0	3.724927
57 29 10	237 22 07	Scargo.	17399.0	4.240525
67 04 26	246 57 47	Scargo .....	15012.7	4.176459
178 37 43	358 37 34	Blackfish Creek.	12850.3	4.108912
226 24 12	46 27 13	Eastham .....	8653.6	3.93719
264 08 22	84 11 28	Mill Hill.	6488.7	3.81216
151 16 22	331 15 24	Mill Hill .....	4195.9	3.62282
206 42 18	26 43 33	Nauset Harbor.	5796.6	3.76317
101 54 35	281 52 32	Pleasant Bay .....	4376.6	3.64114
126 03 10	306 00 08	Mill Hill.	7788.6	3.89146
223 27 28	43 30 36	Eastham .....	9475.7	3.97661
256 47 43	76 50 56	Mill Hill.	6887.7	3.83808
150 59 17	330 58 07	Eastham .....	4982.9	3.69749
67 01 50	247 00 46	Mill Hill.	2427.4	3.38514
1 21 45	181 21 41	German Hill .....	5995.4	3.77782
284 46 13	104 47 20	Scargo.	2389.5	3.37831
124 56 48	304 56 12	North Dennis .....	1533.5	3.18569
255 41 00	75 41 30	Scargo.	1087.2	3.03631
122 33 44	302 33 06	North Dennis .....	1570.2	3.19596
256 34 52	76 35 20	Scargo.	1014.8	3.00637
206 11 59	26 12 19	North Dennis wh. sp .....	1532.4	3.18536
226 27 41	46 28 31	Scargo.	2387.0	3.37786
317 41 47	137 42 53	German Hill .....	3421.0	3.53415
239 00 37	59 02 54	Scargo.	5545.5	3.74394
129 11 02	309 02 28	German Hill .....	23128.5	4.364148
184 31 43	4 32 18	Chatham.	15340.9	4.185851
115 33 14	295 19 10	Shootflying .....	32576.3	4.512902
184 22 12	4 22 46	Chatham.	15375.5	4.186830
207 35 10	27 37 26	German Hil .....	10198.8	4.008550
141 27 13	321 24 01	Shootflying.	10746.7	4.031276
90 06 05	269 53 29	Bourne's Hill .....	26235.9	4.418896
121 49 17	301 32 29	Manomet.	40993.4	4.612714
101 40 35	281 29 34	Bourne's Hill .....	23494.7	4.370970
129 46 43	309 31 28	Manomet.	41134.9	4.614210
0 11 54	180 11 53	Hyannis .....	7264.8	3.86123
274 31 03	94 34 56	German Hill.	8109.9	3.90902
278 06 44	98 10 18	German Hill .....	7514.7	3.87591
236 55 34	56 59 12	North Dennis.	9040.3	3.95618
300 23 10	120 26 01	German Hill .....	6899.2	3.83880
257 16 32	77 20 34	Scargo.	8611.7	3.93509
84 37 59	264 37 12	Hamblin's Hill .....	1634.2	3.21331
160 51 43	340 51 18	Scorton Hill.	2689.9	3.42974
278 26 16	98 30 03	German Hill (Borden) .....	7985.4	3.902294
136 36 20	316 24 53	Manomet.	34559.6	4.538569

## CAPE COD BAY AND PENINSULA—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Barn cupola.	41 42 15.22	469.6	70 19 03.24	74.9
Yarmouth Port spire.	41 42 24.82	765.7	70 14 37.13	858.4
Sursuit Creek.	41 45 32.41	999.7	70 08 37.40	864.0
Morris Island.	41 39 29.48	909.5	69 57 34.14	789.9
Harwich Port.	41 39 51.30	1582.6	70 04 06.57	152.0
West Chatham.	41 40 09.42	290.6	70 01 42.19	976.0
South Dennis.	41 39 06.59	203.3	70 08 12.40	286.9
South Dennis, north spire.	41 40 34.25	1056.6	70 09 24.49	566.5
South Dennis, south spire.	41 40 21.64	667.6	70 09 23.64	546.8
Herring River spire.	41 40 13.01	401.4	70 07 02.58	59.7
Point Gammon 2. 1875.	41 37 04.96	153.0	70 15 39.32	910.3
Mannersen.	41 41 31.14	960.7	70 12 16.86	389.9
Bass River.	41 38 38.44	1185.9	70 12 12.13	280.7
Bass River light-house, 1875.	41 39 06.44	198.7	70 10 10.84	250.8
West Yarmouth spire.	41 38 59.08	1822.7	70 13 46.73	1081.3
Fish-house, north gable.	41 38 19.40	598.5	70 10 38.15	833.0
Harwich belfry (C. & G. S. & B.). 1835-'46.	41 41 12.39	382.3	70 04 35.97	831.8
Marsh.	41 43 51.92	1601.7	69 55 39.95	923.3
Eldridge.	41 44 34.88	1076.0	69 58 39.69	917.1
Pochet.	41 46 39.98	1233.3	69 56 26.09	602.5
Sampson.	41 45 21.74	670.7	69 57 00.43	9.9
Old Harbor.	41 42 19.94	615.1	69 56 01.11	25.7
Camp.	41 43 59.58	1838.0	69 59 33.25	768.4

## CAPE COD BAY AND PENINSULA—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
<i>° / "</i>	<i>° / "</i>		<i>Metres.</i>	
83 49 25	263 45 58	Hamblin's Hill .....	7219.9	3.85853
49 37 32	229 36 21	Shootflying.	3232.7	3.50957
302 02 40	122 04 01	German Hill .....	3305.2	3.51919
235 20 18	55 22 49	Scargo.	6386.0	3.80523
73 56 30	253 53 55	North Dennis .....	5588.8	3.74732
54 49 36	234 48 08	Scargo.	3744.2	3.57336
16 06 89	196 05 40	Monomoy .....	7446.3	3.87194
158 29 38	338 28 49	Chatham.	4683.6	3.67058
318 05 16	138 08 37	Monomoy .....	10512.6	4.021710
72 18 56	252 11 16	Point Gammon.	16833.7	4.226180
232 07 35	52 09 31	Chatham .....	5091.7	3.70686
336 18 53	156 20 39	Monomoy.	9156.7	3.96174
296 50 45	116 56 50	Monomoy .....	14251.9	4.153874
70 06 06	250 01 10	Point Gammon.	11003.9	4.041547
53 22 17	233 18 08	Point Gammon .....	10813.4	4.033962
93 44 52	273 37 16	Shootflying.	15882.2	4.200912
55 07 21	235 03 11	Point Gammon .....	10602.1	4.025392
95 08 22	275 00 46	Shootflying.	15932.0	4.202270
64 10 07	244 04 23	Point Gammon .....	13291.6	4.123578
95 04 58	274 55 47	Shootflying.	19205.7	4.283430
111 05 16	291 03 25	Hyannis .....	4151.6	3.618211
136 10 50	316 07 23	Shootflying.	10368.8	4.015727
29 43 22	209 41 07	Point Gammon 2 .....	9454.6	3.975644
51 53 24	231 49 18	Hyannis.	10879.4	4.036604
173 58 38	353 58 22	German Hill .....	5259.1	3.72091
59 00 07	238 57 50	Point Gammon.	5595.9	3.74788
63 47 16	243 43 38	Point Gammon 2 .....	8476.6	3.92822
146 51 58	326 50 34	Mannersen.	5331.5	3.72685
112 03 12	291 58 31	Shootflying .....	10555.6	4.023482
72 38 29	252 35 23	Hyannis.	6788.8	3.831790
109 06 46	285 05 44	Bass River .....	2253.2	3.35280
246 38 09	66 39 46	South Dennis.	3674.1	3.56515
63 37 12	243 29 50	Point Gammon .....	17143.5	4.234100
72 21 27	252 12 15	Hyannis.	20176.7	4.304850
49 22 13	229 20 08	Chatham .....	5741.0	3.75899
129 04 40	309 01 42	Mill Hill.	7943.8	3.90003
287 40 46	107 42 46	Marsh .....	4359.9	3.63948
2 16 20	182 16 14	Chatham.	5069.0	3.70492
348 22 43	168 23 14	Marsh .....	5293.3	3.72373
38 39 36	218 38 07	Eldridge.	4941.7	3.69388
326 07 40	146 08 34	Marsh .....	3337.3	3.52340
57 46 43	237 45 37	Eldridge.	2711.0	3.43313
76 53 24	256 51 33	Chatham .....	3971.3	3.59893
138 39 13	318 37 28	Eldridge.	5546.8	3.74404
272 29 21	92 51 56	Marsh .....	5396.8	3.73214
345 22 32	165 23 02	Chatham.	4109.0	3.61374

## CAPE COD BAY AND PENINSULA—Continued.

Station.	Latitude.	Seconds in metres.
	° ' "	
Basin.	41 39 48.50	1496.2
Shells.	41 37 52.80	1628.8
Pine.	41 40 08.56	264.1
Mosquito.	41 39 26.91	830.1
Cove.	41 36 56.18	1733.1
Strong.	41 43 12.48	385.0
Crow's Lookout.	41 43 06.96	214.7
Sipson's Island.	41 44 09.28	286.0
Namequoit.	41 45 26.54	818.8
Mayo.	41 46 00.17	5.2
Cumming's (D.) flagstaff, 1868.	41 47 12.17	375.5
Mayo's south chimney.	41 47 20.68	638.0
Hopkins.	41 46 02.05	63.2
Sears.	41 44 38.30	1181.6
Morris Island 2. 1880.	41 39 29.25	902.4
Chatham spire.	41 41 02.79	86.1
Chatham Congregational belfry, 1846.	41 41 15.97	492.7
Chatham Congregational spire, 1868-1880.	41 40 58.54	1805.9
Chatham flagstaff, 1868.	41 40 43.77	1350.3
Chatham, south light-house, 1846.	41 40 17.00	524.5
Chatham, south light-house, 1880.	41 40 17.30	533.8
Chatham, north light-house, 1880.	41 40 18.28	564.0
Stage Harbor (or Harding's Beach) light-house, 1880.	41 39 31.55	973.4

## CAPE COD BAY AND PENINSULA--Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
142 09 09	322 07 45	Chatham -----	4775.5	3.67902
191 20 43	11 21 10	Old Harbor.	4765.4	3.67810
168 05 40	348 04 55	Chatham -----	7501.4	3.87514
195 43 12	15 44 19	Old Harbor.	8562.5	3.93260
199 03 58	19 04 29	Chatham -----	3334.3	3.52301
278 44 09	98 46 05	Basin.	4068.6	3.60945
114 19 58	294 18 36	Pine -----	3119.8	3.49412
158 26 56	338 26 06	Chatham.	4769.9	3.67851
166 46 22	346 45 42	Pine -----	6097.3	3.78514
206 17 09	26 18 24	Basin.	5930.1	3.77306
244 20 43	64 21 56	Marsh -----	2811.6	3.44895
308 23 02	128 24 01	Old Harbor.	2610.3	3.41669
250 03 14	70 05 04	Marsh -----	4069.3	3.60952
293 28 57	113 30 33	Old Harbor.	3638.7	3.56095
208 04 01	28 04 35	Sampson -----	2533.6	3.40373
279 56 25	99 57 53	Marsh.	3099.1	3.49124
217 54 10	37 55 01	Pochet -----	2871.6	3.45813
315 52 01	135 53 22	Marsh.	4066.6	3.60923
38 05 32	218 04 33	Eldridge -----	3343.0	3.52414
104 26 06	284 24 08	Mill Hill.	4209.9	3.62427
318 19 54	138 20 20	Pochet -----	1329.4	3.12367
358 28 32	178 28 35	Sampson.	3408.0	3.53250
340 04 17	160 04 30	Pochet -----	1335.8	3.12574
5 15 47	185 15 37	Sampson.	3685.0	3.56644
224 44 29	44 45 49	Orleans 2.-----	3933.3	3.59476
255 23 01	75 24 51	Mill Hill.	3928.0	3.59417
236 29 35	56 31 42	Rock Point ..-----	5292.0	3.723618
251 44 27	71 49 40	Mill Hill.	11431.1	4.058202
113 22 58	293 21 37	Pine -----	3057.5	3.48536
158 32 16	338 31 27	Chatham.	4689.5	3.67113
133 04 16	313 03 30	Chatham -----	2165.1	3.33549
73 38 48	253 36 07	West Chatham.	5840.2	3.76643
147 06 53	327 06 33	Chatham -----	1276.1	3.10589
66 28 52	246 26 36	West Chatham.	5141.8	3.71111
59 38 29	239 37 13	Pine -----	3049.9	3.48429
136 14 23	316 13 39	Chatham.	2228.5	3.34802
136 27 51	316 26 55	Chatham -----	2849.0	3.45470
212 42 05	32 43 00	Old Harbor.	3526.1	3.54730
29 22 06	209 21 42	Morris Island ..-----	1682.2	3.22588
138 41 16	318 40 03	Chatham.	3849.1	3.58536
85 40 57	265 39 15	Pine -----	3572.2	3.55293
139 23 10	319 22 02	Chatham.	3796.5	3.57938
85 12 34	265 10 51	Pine -----	3580.0	3.55388
139 01 37	319 00 26	Chatham.	3777.3	3.57718
184 33 14	4 33 24	Chatham -----	4306.6	3.63414
271 58 06	91 59 05	Morris Island 2.	2060.2	3.31391



## CAPE COD BAY AND PENINSULA—Continued.

Station.	Latitude.	Seconds in metres.
Hyannis, west spire.	41° 39' 05.77"	178.6
Hyannis, Universalist spire.	41° 39' 14.38"	443.6
Hyannis light-house, 1875.	41° 38' 10.79"	332.5
Bishop and Clerks.	41° 34' 27.44"	846.5
Bishop and Clerks light-house, 1875.	41° 34' 27.52"	849.6
Breakwater, east end, spindle.	41° 37' 27.31"	842.5
Great Rock, spindle.	41° 37' 03.52"	108.6
Marvin's Cottage, cupola.	41° 38' 04.00"	123.4
Marston's Mill.	41° 38' 49.68"	1532.7
Osterville.	41° 37' 52.16"	1609.2
Osterville, spire.	41° 37' 42.08"	1298.2
Osterville Point.	41° 37' 02.13"	65.7
Collier's Ledge.	41° 35' 48.36"	1492.6
Centerville, church.	41° 38' 44.94"	1386.4
Indian Hill.	41° 52' 48.13"	1793.4
East Plymouth.	41° 52' 58.09"	1792.2
Plymouth Cliff.	41° 49' 40.62"	1253.2
Sandwich Orthodox spire.	41° 45' 28.35"	874.6
Spring Hill Academy.	41° 44' 58.86"	1815.5

## NANTUCKET AND VICINITY.

Tuckanuck Telegraph.	41° 18' 14.507"	447.5
Clark's Cove.	41° 15' 20.474"	631.7

## CAPE COD BAY AND PENINSULA—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
36 30 26	216 29 38	Hyannis .....	2779. 8	3. 44402
127 05 57	307 03 34	Shootflying.	6220. 4	3. 79382
39 59 35	219 58 35	Hyannis .....	3262. 7	3. 51358
336 00 24	156 01 15	Point Gammon 2.	4370. 0	3. 64048
311 00 21	131 01 28	Point Gammon 2. ....	3094. 9	3. 49064
70 43 07	250 42 23	Hyannis	1629. 9	3. 21216
146 54 23	326 50 32	Shootflying .....	14731. 2	4. 168237
194 35 06	14 36 43	German Hill.	13406. 6	4. 127318
143 17 05	323 14 49	Hyannis .....	7923. 2	3. 898898
196 17 28	16 19 18	Mannersen.	13617. 3	4. 134090
123 24 36	303 24 01	Hyannis .....	1458. 8	3. 16401
284 32 29	104 33 45	Point Gammon 2.	2744. 2	3. 43842
146 00 32	325 58 06	Shootflying .....	9074. 4	3. 95782
268 47 12	88 48 12	Point Gammon 2.	2108. 8	3. 32403
232 05 49	52 09 45	Mannersen .....	10410. 6	4. 017478
297 14 29	117 16 10	Point Gammon 2.	3977. 4	3. 599598
190 12 51	10 13 20	Hamblin's Hill .....	5650. 6	3. 75209
233 23 02	53 25 46	Shootflying.	7124. 1	3. 85273
278 08 03	98 12 53	Point Gammon .....	10239. 3	4. 010269
166 26 30	346 25 39	Hamblin's Hill.	7546. 2	3. 877728
266 56 07	86 59 14	Hyannis .....	6551. 1	3. 81632
207 00 14	27 01 47	Shootflying.	7108. 0	3. 85175
253 02 21	73 04 50	Hyannis .....	5421. 5	3. 73412
193 54 09	13 55 03	Shootflying.	7793. 3	3. 89172
182 16 53	2 17 04	Shootflying .....	9848. 5	3. 99337
252 39 14	72 42 51	Point Gammon.	7940. 2	3. 89983
295 44 23	115 45 58	Hyannis .....	3664. 4	3. 56400
179 51 28	359 51 28	Shootflying.	4392. 9	3. 64275
3 44 24	183 44 08	Peaked Cliff .....	8247. 3	3. 91631
136 11 00	316 08 42	Manomet.	6867. 9	3. 83683
298 19 57	118 34 05	Scargo .....	33391. 9	4. 523641
324 39 06	144 46 34	Shootflying.	26864. 0	4. 429170
287 53 18	108 07 49	Scargo .....	31746. 8	4. 501700
314 01 42	134 09 33	Shootflying.	22758. 0	4. 357135
149 24 54	329 23 18	Peaked Cliff .....	6560. 3	3. 81692
286 06 57	106 10 30	Scorton Neck.	7679. 6	3. 88534
100 17 06	280 14 57	Mount Schaum .....	4540. 9	3. 65714
134 34 11	314 30 59	Peaked Cliff.	9347. 6	3. 97070

## NANTUCKET AND VICINITY.

275 52 33.5	95 58 00.0	Nantucket Cliff .....	11570. 8	4. 063364
172 48 38.0	352 46 26.8	Hyannis.	36657. 0	4. 564157
231 57 02.5	51 59 33.8	Nantucket Cliff .....	6777. 2	3. 831053
131 01 56.7	310 59 01.6	Tuckanuck Telegraph.	8182. 1	3. 912864

## NANTUCKET AND VICINITY—Continued.

Station.	Latitude.	Seconds in metres.
Windmill Range.	41 16 40.219	1240.8
Weeweeder Pond.	41 14 35.284	1088.4
Gibbs' Pond.	41 16 53.650	1655.1
Squam Head.	41 19 33.485	1032.9
Nantucket south-towered Unitarian church, 1835-1875 (C. & G. S. & B.).	41 16 56.717	1749.7
North Pond.	41 17 38.41	1184.9
Sankaty Head.	41 16 59.91	1848.1
Sankaty Head light-house, 1867.	41 17 01.21	37.3
Forked Pond.	41 14 15.94	491.7
Further Creek.	41 16 39.72	1225.2
Muskeget Island.	41 20 14.11	435.2
Mitchell's house (astronomical station, 1845-1849).	41 16 59.45	1833.9
Shawaukemo.	41 17 01.80	55.5
Bluff.	41 17 31.40	968.5
Coatue Point 2. 1875.	41 18 05.39	166.3
Coatue Point.	41 19 06.62	204.3
Folger.	41 17 17.01	524.7
Folger (astronomical latitude station, 1866).	41 17 16.94	522.6
High School cupola.	41 17 05.98	184.4
Nantucket Baptist church.	41 16 52.66	1624.4
Nantucket north-towered church.	41 17 09.94	306.6
Brant Point light-house, 1867-1875.	41 17 23.20	715.7
Nantucket Range Beacon, 1875 (discontinued Aug. 1, 1880).	41 16 23.92	737.9

## NANTUCKET AND VICINITY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
65 40 37.8	245 38 03.7	Clark's Cove.....	5967.9	3.775823
176 43 31.0	356 43 28.2	Nantucket Cliff.....	1717.8	3.234985
156 36 16.3	336 35 29.1	Windmill Range.....	4199.6	3.623209
101 07 33.2	281 04 12.0	Clark's Cove.....	7242.4	3.859885
171 49 01.3	351 48 12.0	Nantucket light-house.....	12177.0	4.085540
86 49 33.5	266 46 03.6	Windmill Range.....	7415.0	3.870110
69 33 15.4	249 28 39.7	Nantucket Cliff.....	10373.3	4.015918
24 14 32.5	204 13 29.5	Gibbs' Pond.....	5407.3	3.732982
132 56 28.1	312 55 51.3	Nantucket Cliff.....	1770.6	3.248117
200 27 28.0	20 29 34.8	Nantucket light-house.....	12764.6	4.106008
270 53 05	90 55 29	Nantucket Cliff.....	5081.4	3.70598
3 26 50	183 26 43	Clark's Cove.....	4263.0	3.62972
148 57 26	328 56 05	Squam Head.....	5530.2	3.74274
95 04 58	274 59 02	Nantucket Cliff.....	12622.9	4.10116
150 21 43	330 18 32	Nantucket light-house.....	13602.2	4.13361
94 55 35	274 49 51	Nantucket Cliff.....	12547.3	4.09855
118 57 34	298 53 46	Windmill Range.....	9201.1	3.96384
95 21 42	275 18 41	Weeweeder Pond.....	6414.6	3.80717
297 15 37	117 17 51	Clark's Cove.....	5334.4	3.72709
250 03 39	70 06 01	North Pond.....	5314.0	3.72542
287 28 07	107 35 27	Nantucket Cliff.....	16213.6	4.20988
294 47 16	114 52 11	North Pond.....	11439.0	4.05838
132 08 17	312 07 42	Nantucket Cliff.....	1671.9	3.22322
62 32 40	242 32 08	Windmill Range.....	1286.9	3.10953
101 09 36	281 07 05	Nantucket Cliff.....	5430.3	3.73482
182 06 55	2 07 07	Nantucket light-house.....	11809.2	4.07222
205 12 51	25 15 17	Nantucket light-house.....	12036.8	4.08051
280 58 31	101 00 44	Shawaukemo.....	4787.2	3.68008
311 33 44	131 34 47	Shawaukemo.....	2956.2	3.47074
67 09 07	247 07 56	Bluff.....	2699.4	3.43127
298 55 46	118 59 07	Sankaty Head.....	8073.6	3.90707
334 05 39	154 06 36	Gibbs' Pond.....	4560.2	3.65898
123 48 13	303 47 48	Nantucket Cliff.....	1042.4	3.01802
325 31 22	145 31 34	South-towered church.....	759.7	2.88062
180 00	0 00	Folger.....	2.234	0.34911
165 24 52	345 24 49	Folger.....	351.6	2.54602
309 56 45	129 56 55	South-towered church.....	445.4	2.64877
140 43 44	320 43 13	Nantucket Cliff.....	1719.8	3.23548
238 54 03	58 54 09	South-towered church.....	242.4	2.38460
329 59 12	149 59 19	South-towered church.....	470.9	2.67292
138 20 34	318 20 29	Folger.....	291.8	2.46504
101 46 38	281 46 04	Bluff.....	1240.1	3.09345
224 22 18	44 22 54	Coatue Point 2.....	1821.0	3.26030
130 43 50	310 42 41	Bluff.....	3190.8	3.50390
242 52 06	62 53 11	Shawaukemo.....	2563.5	3.40884



## NANTUCKET AND VICINITY—Continued.

Station.	Latitude.	Seconds in metres.
Nantucket Cliff Range Beacon (front), 1875.	41° 17' 37.96"	1170.0
Nantucket Cliff Range Beacon (rear), 1875.	41° 17' 35.55"	1096.0
Nantucket (Borden).	41° 17' 39.86"	1229.0
Tuckanuck Island, north house (Borden).	41° 18' 38.81"	1197.0
Brant Point light-house (Borden), 1835.	41° 17' 24.48"	755.0

## MARTHA'S VINEYARD AND VINEYARD SOUND

Prospect Chilmark (C. and G. S. and B.).	41° 21' 56.838"	1753.0
Davis Hill.	41° 31' 24.305"	749.0
Desert Hill.	41° 29' 28.731"	886.0
East Chop 2. 1875.	41° 28' 04.635"	143.0
Cape Poge.	41° 25' 11.499"	354.0
West Chop 2. 1875.	41° 28' 52.61"	1622.0
Watcha Pond.	41° 20' 52.19"	1609.0
Nashaquitsa Cliff.	41° 20' 00.34"	10.0
Herring Pond.	41° 20' 47.35"	1460.0
Edgartown.	41° 23' 51.77"	1596.0
Edgartown spire.	41° 23' 18.64"	575.0
Edgartown light-house, 1875.	41° 23' 27.29"	841.0
Molasha Hill.	41° 20' 29.02"	895.0
Gay Head.	41° 20' 50.30"	1243.0
Gay Head light-house (Borden), 1835.	41° 20' 54.54"	1682.0
Gay Head light-house, 1843-45.	41° 20' 54.10"	1668.0

## NANTUCKET AND VICINITY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
250 45 18	70 46 27	Coatue Point 2 -----	2568.9	3.40974
283 30 14	103 32 26	Shawaukemo.	4769.8	3.67850
249 23 03	69 24 13	Coatue Point 2 -----	2615.6	3.41757
16 59 59	196 59 58	Bluff.	133.9	2.12675
207 04 02	27 06 37	Nantucket light-house -----	11936.3	4.07687
323 51 45	143 52 13	South-towered church.	1647.9	3.21693
277 57 28	98 03 35	Nantucket -----	13052.0	4.11568
282 42 49	102 49 23	South-towered church.	14249.8	4.15381
107 40 01	287 39 19	Nantucket -----	1563.8	3.19417
31 11 25	211 11 10	South-towered church.	1001.2	3.00051

## MARTHA'S VINEYARD AND VINEYARD SOUND.

219 19 40.2	39 22 25.8	Indian -----	9172.2	3.962471
266 18 36.5	86 29 03.5	Sampson.	22088.2	4.344161
302 56 44.7	123 05 03.7	Cape Poge light-house -----	20852.1	4.319151
7 48 07.7	187 47 27.0	Indian.	10511.0	4.021646
2 50 03.3	182 49 43.7	Prospect Chilmark -----	13958.0	4.144824
323 11 30.1	143 13 56.2	Indian.	8551.3	3.932032
127 21 09.5	307 17 18.7	Davis' Hill -----	10160.2	4.006904
65 56 35.1	245 52 03.8	Indian.	10420.2	4.017875
119 30 31.7	299 26 02.2	East Chop 2 -----	10856.5	4.035691
93 21 19.8	273 12 19.3	Indian.	19001.4	4.278786
132 25 13	312 22 47	Davis' Hill -----	6940.6	3.84140
296 35 19	116 36 43	East Chop 2.	3304.9	3.51916
99 55 21	279 49 55	Prospect Chilmark -----	11624.9	4.06539
148 14 21	328 11 41	Indian. •	10690.1	4.02898
171 16 11	351 15 55.5	Prospect Chilmark -----	3635.8	3.56060
256 52 02	77 02 13.5	Sampson.	22067.3	4.34375
96 40 26	276 31 39	Prospect Chilmark -----	18646.6	4.27060
126 04 56	305 58 55	Indian.	15701.8	4.19595
78 01 14	257 53 21	Prospect Chilmark -----	16989.9	4.23019
108 14 05	288 08 58	Indian.	11361.4	4.05543
82 40 02	262 30 50	Prospect Chilmark -----	19570.4	4.29160
108 38 42	288 32 15	Indian.	14331.0	4.15628
149 23 47	329 21 22	East Chop 2 -----	9942.8	3.99751
310 38 40	130 39 26	Sampson.	2152.9	3.33303
242 50 46	62 53 16	Prospect Chilmark -----	5941.0	3.77386
130 33 23	310 28 30	Cuttyhunk.	13575.0	4.13274
135 14 46	315 10 56	Cuttyhunk -----	11500.6	4.06072
235 28 19	55 34 38	Indian.	16156.6	4.20835
134 24 32	314 20 38	Cuttyhunk -----	11484.4	4.06011
235 38 30	55 44 46	Indian.	15994.5	4.20397
134 23 19	314 19 25	Cuttyhunk -----	11507.5	4.06098
235 33 50	55 40 05	Indian.	15986.0	4.20374

## MARTHA'S VINEYARD AND VINEYARD SOUND—Co

Stations.	Latitude.	Seconds in metres.
	° ' "	
Gay Head light-house, 1875.	41 20 54.59	1684.0
East Chop.	41 28 04.80	148.1
East Chop Telegraph.	41 28 04.72	145.6
East Chop light-house, 1875.	41 28 13.44	414.5
Tarpaulin Cove light-house, 1835-'45 (C. and G. S. and B.).	41 28 07.90	243.7
Kotayma House, north tower.	41 21 30.10	928.5
Observatory with red roof, flag-staff.	41 26 12.76	393.6
Prospect House, cupola, flag-staff.	41 26 41.34	1275.2
Union Chapel.	41 27 16.82	518.9
Highland House, north tower.	41 27 50.26	1550.4
Seaview House, north tower.	41 27 28.54	880.4
No Man's Land (C. & G. S. & B.).	41 15 11.70	360.9
Bowman's Point.	41 32 36.46	1124.8
Bowman's Hill observatory.	41 32 38.10	1175.4
Nobska Point light-house, 1835-'75 (C. & G. S. & B.).	41 30 57.24	1765.9
White house, south gable.	41 32 46.42	1432.1
White house, chimney.	41 32 09.08	280.1
Menauhant Hotel, west chimney.	41 33 01.00	30.8
Menauhant Landing, flagstaff.	41 32 59.68	1841.2
Wood's Holl, Episcopal spire.	41 31 19.86	612.7
Davis Neck.	41 32 54.42	1678.9
Monaunt Hill.	41 33 05.51	169.9
Sampson (Borden).	41 22 41.51	1280.5

## MARTHA'S VINEYARD AND VINEYARD SOUND—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
216 50 44	36 57 40	Davis Hill -----	24294. 1	4. 38550
255 20 32	75 24 01	Prospect Chilmark.	7604. 3	3. 88106
326 03 48	146 06 59	Sampson -----	12005. 8	4. 07939
65 54 57	245 50 26	Indian.	10422. 0	4. 01795
99 28 08	279 21 01	Naushon -----	15154. 1	4. 18053
128 57 22	308 53 28	Wood's Holl.	10511. 6	4. 02167
127 14 39	307 10 58	Davis' Hill -----	9736. 4	3. 98840
114 41 44	294 40 29	West Chop 2.	2893. 2	3. 46138
303 03 03	123 06 14	Indian -----	7979. 2	3. 90196
355 37 28	175 37 53	Prospect Chilmark.	11480. 7	4. 05997
118 48 51	298 42 00	Indian -----	16457. 4	4. 21636
219 01 41	39 02 32	Sampson.	2848. 4	3. 45460
82 30 29	262 27 36	Indian -----	6136. 3	3. 78791
278 17 44	98 23 51	Cape Poge.	13022. 7	4. 11470
206 11 43	26 12 19	East Chop 2 -----	2864. 2	3. 45700
284 27 19	104 32 24	Cape Poge.	11070. 8	4. 04418
162 39 15	342 39 02	East Chop 2 -----	1545. 3	3. 18901
323 39 05	143 42 04	Sampson.	10529. 6	4. 02241
326 13 56	146 16 57	Sampson -----	11442. 7	4. 05853
68 53 54	248 49 13	Indian.	10565. 7	4. 02390
295 36 42	115 40 53	Cape Poge -----	9768. 3	3. 98982
72 51 45	252 46 55	Indian.	10633. 6	4. 02668
151 35 57	331 31 11	Cuttyhunk -----	21162. 2	4. 32556
203 52 57	23 55 34	Prospect Chilmark.	13671. 3	4. 13581
331 47 15	151 51 55	Sampson -----	20810. 4	4. 31828
26 47 39	206 44 37	Indian.	14157. 3	4. 15098
358 50 38	178 50 42	West Chop 2 -----	6957. 9	3. 84248
65 27 54	245 25 31	Davis' Hill.	5477. 7	3. 73860
11 02 33	191 01 40	Indian -----	9759. 3	3. 98942
68 40 29	248 37 09	Desert Hill.	7499. 3	3. 87502
343 19 41	163 20 55	East Chop 2 -----	9074. 0	3. 95780
28 05 44	208 02 27	Indian.	14672. 7	4. 16651
315 30 25	135 33 56	East Chop 2 -----	10566. 0	4. 02391
10 07 22	190 06 22	Indian.	11981. 5	4. 07851
329 35 08	149 39 11	Cape Poge -----	16790. 0	4. 22505
38 01 31	217 56 32	Indian.	16997. 3	4. 23038
329 34 26	149 38 28	Cape Poge -----	16745. 2	4. 22389
38 09 42	218 04 43	Indian.	16977. 4	4. 22987
305 58 51	126 02 48	East Chop 2 -----	10243. 1	4. 01043
6 46 37	186 46 02	Indian.	10348. 8	4. 01489
340 36 44	160 39 53	Sampson -----	20031. 3	4. 30171
35 57 42	215 53 09	Indian.	16292. 6	4. 21199
345 46 00	165 48 19	Sampson -----	19848. 1	4. 29772
39 57 48	219 52 25	Indian.	17649. 4	4. 24673
86 30 32	266 20 05	Prospect Chilmark -----	22082. 6	4. 34405
109 28 44	289 21 03	Indian.	17191. 4	4. 23531



## MARTHA'S VINEYARD AND VINEYARD SOUND—Co

Station.	Latitude.	Seconds in metres.
	° / "	
Succonneset.	41 33 31.43	969.6
Succonneset (Borden).	41 33 34.76	1072.4
West Chop.	41 28 54.29	1674.8
Cape Poge light-house (Borden), 1835.	41 25 18.54	571.9
Holmes' Hole spire.	41 27 15.15	467.3
Holmes' Hole wind-mill (Borden).	41 27 14.81	456.8
Holmes' Hole (West Chop) light-house, 1835-'45 (C. & G. S. & B.).	41 28 57.66	1778.7
Holmes' Hole (West Chop) light-house, 1875.	41 28 51.06	1575.1
Cotuit Neck.	41 35 31.16	961.3

## BUZZARD'S BAY.

Falmouth (C. & G. S. and Borden).	41 35 53.114	1638.6
Naushon.	41 29 25.030	772.2
Mishaum Point.	41 30 56.112	1731.1
Swift's Hill.	41 34 02.457	75.7
West Island.	41 34 56.619	1746.6
Angelica Point.	41 38 28.974	894.0
Pine Hill (C. & G. S. and Borden).	41 42 31.126	960.2
Wood's Holl.	41 31 38.796	1196.9
Great Hill (C. & G. S. and Borden).	41 42 33.278	1026.6
Mendal (Borden).	41 42 03.029	93.4
New Bedford court house (Borden).	41 38 03.723	114.9
Dartmouth (C. & G. S. and Borden).	41 34 11.594	357.7

## MARTHA'S VINEYARD AND VINEYARD SOUND—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
1 44 18	181 44 01	Sampson .....	20049. 3	4. 30210
49 35 50	229 27 50	Indian.	22088. 2	4. 34416
240 17 24	60 24 06	Hyannis .....	16123. 2	4. 20745
109 46 24	289 40 43	Falmouth.	12645. 3	4. 10193
46 31 14	226 28 20	Indian .....	8404. 8	3. 92453
94 45 47	274 40 19	Naushon.	11530. 5	4. 06185
29 46 21	209 45 02	Sampson (Borden) .....	5580. 3	3. 74666
92 42 02	272 33 01	Indian.	18997. 7	4. 27870
309 38 06	129 42 56	Sampson .....	13207. 2	4. 12081
65 44 56	245 42 04	Indian.	6634. 4	3. 82180
222 49 07	42 54 18	Succonnesset (Borden) .....	15991. 6	4. 20389
231 32 49	51 44 41	Hyannis.	31745. 9	4. 50169
46 47 36	226 44 37	Indian .....	8598. 4	3. 93442
94 11 22	274 05 48	Naushon.	11690. 4	4. 06783
95 45 48	275 40 17	Desert Hill .....	11665. 9	4. 06692
133 03 46	313 01 21	Davis Hill.	6926. 9	3. 84054
249 06 38	69 12 08	Hyannis .....	12327. 9	4. 090888
7 42 26	187 40 54	Sampson.	23949. 7	4. 379300

## BUZZARD'S BAY.

183 30 32.8	3 31 37.5	Manomet .....	36646. 7	4. 564035
246 40 36.4	66 51 24.7	Shootflying.	24574. 7	4. 390489
64 18 42.8	244 11 06.5	Cuttyhunk .....	17761. 7	4. 249485
220 53 15.1	40 58 12.1	Falmouth.	15846. 9	4. 199944
278 57 06.3	99 05 31.9	Naushon .....	17919. 2	4. 253320
350 45 14.3	170 46 03.2	Cuttyhunk.	10665. 3	4. 027971
77 40 44.5	257 28 17.9	Mishaum Point .....	26719. 4	4. 426827
44 31 29.2	224 27 28.7	Naushon.	11997. 9	4. 079106
276 16 15.3	96 23 26.7	Swift's Hill .....	15153. 1	4. 180503
264 05 20.4	84 13 28.5	Falmouth.	17120. 1	4. 233507
308 34 05.4	128 39 00.6	Swift's Hill .....	13176. 7	4. 119807
291 21 18.3	111 27 10.2	Falmouth.	13176. 0	4. 119784
277 59 36.0	98 08 20.8	Shootflying .....	18423. 8	4. 265378
175 08 52.8	355 07 53.1	Manomet.	24386. 1	4. 387143
87 00 55.3	266 49 16.1	Mishaum Point .....	24493. 7	4. 389055
114 30 11.1	294 23 47.0	West Island.	14745. 2	4. 168651
28 56 16.9	208 47 51.3	Cuttyhunk .....	36580. 9	4. 563254
324 51 59.0	144 56 08.2	Falmouth.	15089. 5	4. 178675
7 45 54.3	187 43 53.1	Cuttyhunk .....	31388. 6	4. 496772
297 14 08.2	117 24 42.6	Falmouth.	24862. 7	4. 395548
0 32 35.8	180 32 29.4	Cuttyhunk .....	23720. 2	4. 375118
278 40 15.8	98 52 44.6	Falmouth.	26413. 3	4. 421821
334 10 48.7	154 14 37.2	Cuttyhunk .....	18389. 0	4. 264559
264 39 02.7	84 55 26.4	Falmouth.	34473. 0	4. 537479

## BUZZARD'S BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Eldridge.	41 31 46.109	1422.4	71 05 08.269	191.7
Gooseberry Neck.	41 29 20.083	619.6	71 02 19.612	455.0
Almy.	41 30 42.286	1304.5	71 01 49.855	1156.0
Quicksand.	41 30 01.683	51.9	71 07 12.194	282.8
Nootas (Borden).	41 32 13.094	404.0	71 07 25.874	599.8
Pasque.	41 26 57.82	1783.8	70 50 04.43	102.8
Sconticut Neck.	41 35 02.65	81.7	70 51 20.39	472.2
Round Hill.	41 32 24.79	764.9	70 55 50.59	1172.6
Clark's Point.	41 35 34.15	1053.1	70 54 03.69	85.4
New Bedford Fort.	41 37 27.06	834.9	70 54 10.37	240.0
Wild Harbor.	41 38 22.19	684.7	70 39 09.05	209.5
Wenauwet Neck.	41 40 58.14	1793.7	70 39 41.00	948.2
Sippican Neck.	41 40 35.93	1108.4	70 42 58.05	1342.6
Tempes Knob.	41 42 58.46	1803.6	70 39 48.84	1128.9
Indian Neck.	41 43 33.27	1026.4	70 41 27.05	625.2
Cromeset Neck.	41 43 41.74	1287.6	70 43 20.57	475.5
Long Neck.	41 44 20.21	623.6	70 38 45.42	1049.5
Back River Harbor.	41 43 18.58	573.3	70 36 50.49	1167.0
Hog Island Harbor.	41 36 15.84	488.6	70 38 57.00	1319.8
Nashawena.	41 25 30.97	955.4	70 52 06.61	153.5
Naushon, southwest.	41 27 01.82	56.1	70 47 19.97	463.5
Naushon, northeast.	41 30 35.72	1101.7	70 42 48.91	1134.2
Penikese.	41 26 58.17	1794.6	70 55 26.91	624.7

## BUZZARD'S BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
104 36 20.2	284 34 49.0	Nootas. ....	3295.3	3.517897
46 13 00.8	226 08 42.4	East Rock.	12540.9	4.098329
247 07 31.1	67 10 52.0	Mishaum Point. ....	7630.2	3.882535
310 48 37.4	130 52 47.0	Cuttyhunk.	11566.0	4.063182
63 52 05.2	243 45 35.4	East Rock. ....	15214.7	4.182265
321 23 15.1	141 27 05.0	Cuttyhunk.	12920.4	4.111276
221 43 16.3	41 44 38.4	Eldridge. ....	4317.0	3.635184
175 32 19.6	355 32 10.6	Nootas.	4064.2	3.608975
244 58 18.0	65 02 02.4	Dartmouth. ....	8651.3	3.937081
309 04 44.8	129 12 17.3	Cuttyhunk.	20438.7	4.310454
69 08 02	249 04 05	Cuttyhunk. ....	8902.3	3.94950
126 17 56	306 13 10	Mishaum Point.	12429.7	4.09446
317 47 31	137 52 01	Naushon. ....	14053.7	4.14779
19 52 38	199 49 31	Cuttyhunk.	19277.9	4.28506
289 23 19	109 30 48	Naushon. ....	16654.1	4.22152
232 05 55	52 08 54	Sconticut Neck.	7932.1	3.89939
284 23 43	104 25 31	Sconticut Neck. ....	3905.4	3.59166
22 59 12	202 58 01	Round Hill.	6345.4	3.80246
318 31 21	138 33 14	Sconticut Neck. ....	5945.0	3.77415
357 27 24	177 27 28	Clark's Point.	3486.7	3.54241
65 56 09	245 49 23	West Island. ....	15519.6	4.19088
353 40 19	173 40 44	Swift's Hill.	8062.0	3.90644
352 45 42	172 46 29	Swift's Hill. ....	12927.1	4.11150
62 03 03	241 58 54	Angelica Point.	9807.5	3.99156
46 20 26	226 18 28	Angelica Point. ....	5671.8	3.75372
171 51 55	351 51 40	Great Hill.	3657.1	3.56314
44 52 33	224 50 27	Sippican Neck. ....	6203.1	3.79261
80 59 49	260 57 28	Great Hill.	4952.8	3.69485
295 19 04	115 20 09	Tempes Knob. ....	2511.5	3.39993
54 46 40	234 45 24	Great Hill.	3208.6	3.50631
275 40 40	95 41 56	Indian Neck. ....	2636.5	3.42102
359 55 02	179 55 02	Great Hill.	2112.5	3.32479
296 53 16	116 56 27	Pine Hill. ....	7434.8	3.87127
62 35 50	242 32 47	Great Hill.	7162.1	3.85504
290 12 39	110 14 33	Pine Hill. ....	4234.9	3.62684
81 13 19	261 09 00	Great Hill.	9122.2	3.96010
351 34 38	171 34 56	Swift's Hill. ....	4159.7	3.61906
80 27 22	260 20 28	West Island.	14652.4	4.16591
192 24 47	12 26 37	West Island. ....	17869.8	4.25212
235 29 35	55 34 35	Naushon.	12758.5	4.10580
117 38 05	297 31 29	Mishaum Point. ....	15612.1	4.19346
169 11 04	349 09 44	West Island.	14913.2	4.17357
131 34 55	311 30 35	West Island. ....	12135.8	4.08407
223 09 26	43 12 18	Swift's Hill.	8746.4	3.94183
270 03 07	90 06 40	Pasque. ....	7485.3	3.87421
14 36 00	194 35 36	Cuttyhunk.	3292.5	3.51753

## BUZZARD'S BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Penikese (Borden).	41 26 58.19	1795.3	70 55 27.10	629.1
Padanaram.	41 35 39.27	1211.4	70 56 35.73	827.5
Padanaram, gray spire.	41 35 20.12	620.8	70 56 28.07	650.1
New Bedford Baptist church.	41 38 12.37	381.6	70 55 36.98	855.9
New Bedford Beacon.	41 36 33.62	1037.2	70 53 28.73	665.2
Fair Haven, black spire.	41 38 09.81	302.6	70 54 18.85	436.2
Pamanset River.	41 31 41.30	1274.0	70 59 30.99	718.5
Monument church.	41 44 32.45	1001.1	70 35 49.73	1149.1
Pocasset spire.	41 41 41.55	1281.8	70 36 18.28	422.7
South Pocasset spire.	41 40 36.28	1119.2	70 36 22.83	528.1
Scraggy Neck.	41 39 59.28	1828.8	70 39 15.57	360.1
North Falmouth, spire.	41 38 33.32	1027.9	70 37 07.29	168.7
Falmouth, spire.	41 33 14.95	461.2	70 37 12.52	290.1
Mattapoisett Neck.	41 37 46.57	1436.7	70 48 11.30	261.5
Mattapoisett, gray spire.	41 39 43.93	1355.2	70 49 12.28	284.1
Sippican church.	41 42 09.92	306.0	70 45 47.88	1107.0
Wareham Baptist church.	41 45 27.19	838.9	70 43 03.63	83.8
Charles Neck.	41 40 21.61	666.7	70 41 45.04	1041.8
West Island 2.	41 35 25.09	774.1	70 49 04.85	112.3
New Falmouth.	41 33 42.42	1308.7	70 37 52.42	1214.6
Ned's Point light-house, 1844.	41 39 03.34	103.0	70 47 46.11	1067.0
Dumpling Rock (Round Hill) light-house. (C. & G. S. & B.), 1835-'44.	41 32 17.88	551.6	70 55 19.09	442.5
Clark's Point light-house (C. & G. S. & B.). 1835-'44.	41 35 34.28	1057.5	70 54 03.91	90.5

## BUZZARD'S BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
276 01 55	96 11 43	Indian .....	20695.7	4.31588
14 31 35	194 31 12	Cuttyhunk.	3292.2	3.51748
272 33 21	92 35 02	Clark's Point .....	3524.9	3.54715
350 06 28	170 06 58	Round Hill.	6090.5	3.78465
262 36 50	82 38 26	Clark's Point .....	3372.1	3.52790
350 52 30	170 52 55	Round Hill.	5478.6	3.73867
316 33 12	136 40 33	Naushon .....	22385.1	4.34996
9 43 15	189 42 09	Mishaum Point.	13654.9	4.13529
313 20 41	133 22 06	Sconticut Neck .....	4087.9	3.61150
23 49 00	203 48 37	Clark's Point.	2005.3	3.30218
324 23 42	144 25 41	Sconticut Neck .....	7100.2	3.85127
355 49 08	175 49 18	Clark's Point.	4815.2	3.68261
255 15 59	75 18 25	Round Hill .....	5282.3	3.72282
294 03 39	114 05 08	Mishaum Point.	3417.3	3.53368
31 38 53	211 38 13	Back River Harbor .....	2676.6	3.42759
84 42 15	264 40 18	Long Neck.	4677.2	3.61036
110 50 11	290 45 30	Cromeset Neck .....	10442.9	4.01882
115 48 03	295 44 38	Indian Neck.	7926.7	3.89909
89 58 14	269 53 51	Sippican Neck .....	9142.0	3.96104
132 39 30	312 37 13	Tempes Knob.	6475.7	3.81129
357 07 03	177 07 07	Wild Harbor .....	2999.2	3.47700
102 24 46	282 22 18	Sippican Neck.	5269.3	3.72175
115 01 26	294 57 33	Sippican Neck .....	8953.6	3.95200
89 25 16	269 19 25	Angelica Point.	12221.9	4.08714
49 21 48	229 20 09	Wood's Holl .....	4552.6	3.65826
55 16 57	235 12 05	Naushon.	12442.6	4.09491
297 09 35	117 16 00	Swift's Hill .....	15119.6	4.17954
341 54 20	161 56 45	Naushon.	16276.1	4.21155
305 17 09	125 24 15	Swift's Hill .....	18210.8	4.26033
1 16 23	181 16 17	West Island.	8866.3	3.94774
284 35 42	104 39 46	Wenauet Neck .....	8768.4	3.94292
326 01 32	146 06 22	Swift's Hill.	18125.9	4.25830
294 40 30	114 44 38	Back River Harbor .....	9491.8	3.97735
330 32 52	150 35 07	Wenauet Neck.	9530.8	3.97913
295 19 33	115 23 16	Wild Harbor .....	8603.0	3.93465
25 05 27	205 04 40	Angelica Point.	3836.7	3.58396
217 42 03	37 44 09	Angelica Point .....	7171.5	3.85561
298 05 11	118 11 25	Wood's Holl.	14802.3	4.17033
33 34 24	213 33 12	Wood's Holl .....	4576.6	3.66054
49 32 05	229 27 39	Naushon.	12225.6	4.08727
305 46 12	125 52 21	Swift's Hill .....	15860.2	4.20031
345 55 52	165 58 00	Naushon.	18391.6	4.26462
4 26 03	184 25 34	Cuttyhunk .....	13088.5	4.11689
47 10 39	227 09 21	Mishaum Point.	3710.5	3.56943
280 00 58	100 04 06	West Island .....	6660.2	3.82349
27 29 12	207 27 04	Mishaum Point.	9672.1	3.98552

## BUZZARD'S BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Bird Island light-house (C. & G. S. & B.). 1835-'44.	41 40 09.65	297.6	70 43 04.14	95.8
Cuttyhunk light-house (C. & G. S. & B.). 1835-'44.	41 24 52.36	1615.3	70 57 00.18	4.2
Naushon (Borden).	41 29 24.97	770.4	70 44 33.34	773.4
Wing's Neck light-house, 1875.	41 40 49.38	1523.4	70 39 41.75	965.6
Palmer's Island light-house, 1875.	41 37 37.27	1149.7	70 54 34.72	803.7
Quicksand (Borden).	41 30 01.73	53.4	71 07 12.18	282.5
Joe Sanford (Borden).	41 35 37.56	1158.7	71 07 55.53	1286.1

## TAUNTON RIVER.

Pine Hill (Rhode Island).	41 38 00.469	14.5	71 20 35.806	828.7
Mount Hope 2 (Rhode Island). 1874.	41 40 26.515	818.0	71 14 26.094	603.6
Hog Island 3 (Rhode Island). 1874.	41 38 40.481	1248.8	71 16 50.822	1176.0
Mound (Rhode Island).	41 38 14.042	433.2	71 13 11.906	275.4
Chase.	41 40 23.917	737.9	71 11 16.462	380.9
Gardner's Neck.	41 42 33.742	1040.9	71 12 24.807	573.5
City.	41 41 43.770	1350.3	71 10 19.091	441.4
Somerset 2. 1874.	41 43 44.048	1358.9	71 10 08.164	188.7
Calvary.	41 43 40.822	1259.4	71 08 05.039	116.4
Steep Brook.	41 44 56.972	1757.6	71 07 23.164	535.2
Wood.	41 45 03.097	95.5	71 08 27.346	631.8
Bluff.	41 45 54.516	1681.9	71 07 49.704	1148.1
Burns.	41 44 26.702	823.8	71 08 52.719	1218.2
Ridge.	41 45 33.464	1032.4	71 07 10.982	253.7

## BUZZARD'S BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / //	° / //		<i>Metres.</i>	
330 46 42*	150 49 44	Swift's Hill.....	12977.5	4.11319
42 06 35	222 02 25	West Island.	13911.3	4.11432
133 10 45	313 03 51	Nootas .....	19888.9	4.29861
178 04 33	358 04 22	Mishaum Point.	11228.7	4.05033
135 31 30	315 23 59	New Bedford court-house .....	22452.8	4.35127
110 20 25	290 08 59	Dartmouth.	25555.2	4.40748
2 48 50	182 48 11	Indian .....	27881.8	4.44532
17 10 04	197 06 58	Desert Hill.	21973.5	4.34190
334 55 53	155 02 20	Prospect Chilmark .....	32016.2	4.50537
316 37 24	136 44 11	Desert Hill.	20716.7	4.31632
175 31 13	355 31 04	Nootas (Borden) .....	4065.1	3.60907
299 36 00	119 43 23	Cuttyhunk.	17881.7	4.25241
353 46 48	173 47 08	Nootas (Borden) .....	6345.6	3.80247
83 08 51	263 03 57	Quaker.	10331.1	4.01415

## TAUNTON RIVER.

31 55 58.6	211 51 27.3	McSparran .....	17933.0	4.253654
307 30 33.8	127 34 04.6	Quaker.	9270.7	3.967114
62 15 31.6	242 11 25.8	Pine Hill .....	9668.8	3.985375
6 47 47.5	186 47 12.8	Quaker.	10226.1	4.009711
342 42 37.5	162 43 38.9	Quaker .....	7208.4	3.857842
225 39 19.2	45 40 55.4	Mount Hope 2.	4681.3	3.670366
157 13 25.6	337 12 36.3	Mount Hope 2 .....	4432.8	3.646681
25 46 07.3	205 44 43.3	Quaker.	6736.7	3.828449
33 42 01.7	213 40 45.0	Mound .....	4815.6	3.682651
91 03 50.6	271 01 44.5	Mount Hope 2.	4387.3	3.642195
7 44 52.7	187 44 21.4	Mound .....	8085.9	3.907727
338 27 33.1	158 28 18.6	Chase.	4305.9	3.634060
117 57 10.9	297 55 47.3	Gardner's Neck .....	3290.3	3.517238
67 22 33.6	247 19 49.3	Mount Hope 2.	6189.9	3.791686
44 24 16.2	224 21 24.6	Mount Hope 2 .....	8526.8	3.930786
3 53 43.5	183 53 36.2	City.	3719.3	3.570466
92 00 50.6	271 59 28.7	Somerset 2 .....	2847.4	3.454456
71 00 27.8	250 57 34.9	Gardner's Neck.	6351.4	3.802868
22 23 25.9	202 22 58.0	Calvary .....	2540.8	3.404971
59 28 21.2	239 26 31.4	Somerset 2.	4427.2	3.646127
277 15 24.1	97 16 06.8	Steep Brook .....	1494.9	3.174610
348 31 06.4	168 31 21.2	Calvary.	2590.1	3.413318
28 44 00.6	208 43 35.5	Wood .....	1809.1	3.257462
340 56 43.0	160 57 00.7	Steep Brook.	1878.3	3.273754
245 42 09.5	65 43 09.1	Steep Brook .....	2270.3	3.356075
208 14 48.9	28 15 30.8	Bluff.	3075.6	3.487933
125 59 14.1	305 58 48.3	Bluff .....	1105.4	3.043521
48 46 57.4	228 45 49.8	Burns.	3125.4	3.494898



## TAUNTON RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Depot.	41 46 31.092	959.3	71 07 15.068	348.0
Terry.	41 46 31.456	970.5	71 06 43.069	994.7
Richmond Hill.	41 48 27.290	841.9	71 07 43.348	1000.6
Mack.	41 47 30.986	956.0	71 07 02.325	53.7
Marsh.	41 47 38.184	1178.0	71 07 33.802	780.5
Nichols.	41 48 25.970	801.2	71 06 59.357	1370.2
New.	41 49 33.063	1020.1	71 06 58.418	1348.2
Bare Top.	41 48 52.846	1630.4	71 06 00.440	10.2
Assonet.	41 47 25.348	782.1	71 05 56.878	1313.3
Graveyard.	41 49 34.476	1063.7	71 07 28.940	667.8
Schoolhouse Hill.	41 50 01.412	43.6	71 06 17.556	405.1
Beveled Barn, ball on cupola.	41 50 12.731	392.8	71 07 09.139	210.9
Telegraph.	41 50 59.358	1831.3	71 06 50.326	1160.9
Florence.	41 50 45.033	1389.4	71 06 58.033	1338.8
High.	41 50 57.520	1774.6	71 06 29.891	689.6
Brown's Hill.	41 47 25.291	780.3	71 06 27.655	638.6
Blackbeard.	41 40 28.88	891.0	71 10 58.83	1360.8
Fall River.	41 42 39.25	1210.9	71 08 45.54	1052.8
Fall River 2. 1861.	41 42 39.74	1226.0	71 08 45.38	1049.1
Mattapoissett.	41 42 40.47	1248.6	71 12 51.76	1196.6
Globe Village chimney.	41 41 17.27	532.8	71 10 23.84	551.3
Slade.	41 43 41.20	1271.1	71 10 09.12	210.8
Somerset.	41 44 07.60	234.5	71 10 06.49	150.0

## TAUNTON RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
356 57 38.7	176 57 41.4	Ridge.....	1780.4	3.250528
30 27 26.5	210 26 21.4	Burns.....	4451.6	3.648517
53 29 11.9	233 28 27.4	Bluff.....	1915.1	3.282192
89 07 59.4	269 07 38.1	Depot.....	739.1	2.868720
349 40 28.9	169 40 47.7	Depot.....	3643.9	3.561567
338 42 55.8	158 43 36.0	Terry.....	3835.2	3.583785
151 24 14.9	331 23 47.5	Richmond Hill.....	1978.5	3.296337
346 23 17.4	166 23 30.3	Terry.....	1889.7	3.276386
286 59 19.2	106 59 40.2	Mack.....	760.0	2.880792
171 43 29.2	351 43 22.8	Richmond Hill.....	1531.0	3.184964
92 18 06.1	272 17 36.8	Richmond Hill.....	1016.3	3.007025
28 20 44.5	208 20 21.5	Marsh.....	1675.1	3.224034
27 04 23.4	207 03 53.4	Richmond Hill.....	2278.9	3.357718
0 36 00.7	180 36 00.1	Nichols.....	2070.1	3.315990
132 50 39.4	312 50 00.8	New.....	1824.8	3.261220
71 38 48.7	251 37 40.1	Richmond Hill.....	2502.8	3.398432
127 52 24.6	307 51 13.6	Richmond.....	3113.5	3.493253
178 15 22.1	358 15 19.7	Bare Top.....	2700.8	3.431485
9 06 57.6	189 06 48.0	Richmond Hill.....	2099.4	3.322089
302 09 17.4	122 10 16.4	Bare Top.....	2412.8	3.382516
63 14 12.5	243 13 24.9	Graveyard.....	1845.0	3.266001
34 17 48.5	214 16 51.3	Richmond Hill.....	3514.7	3.545888
21 09 55.2	201 09 42.0	Graveyard.....	1265.6	3.102298
286 20 51.3	106 21 25.7	School-house Hill.....	1240.4	3.093570
16 47 28.6	196 47 16.1	Beveled Barn.....	1502.6	3.176844
337 04 22.0	157 04 43.9	School-house Hill.....	1941.1	3.288045
14 25 12.9	194 25 05.5	Beveled Barn.....	1029.0	3.012409
201 54 48.2	21 54 53.3	Telegraph.....	476.4	2.677972
96 51 41.2	276 51 27.6	Telegraph.....	474.8	2.676518
59 18 59.4	239 18 40.7	Florence.....	754.9	2.877910
34 05 25.2	214 04 30.5	Bluff.....	3381.4	3.529096
137 35 32.0	317 34 41.5	Richmond Hill.....	2590.9	3.413448
17 33 47	197 33 25	Pocasset.....	2571.2	3.41014
89 00 23	268 58 05	Mount Hope.....	4797.7	3.68103
62 29 50	242 26 03	Mount Hope.....	8884.4	3.94863
30 48 42	210 46 51	Pocasset.....	7536.0	3.87714
37 24 38	217 23 09	Blackbeard.....	5081.7	3.70601
62 25 28	242 21 41	Mount Hope.....	8894.5	3.94912
327 14 22	147 15 37	Blackbeard.....	4827.4	3.68371
27 47 47	207 46 44	Mount Hope.....	4685.0	3.67071
74 18 11	254 15 30	Mount Hope.....	5823.7	3.76520
126 53 58	306 52 20	Mattapoisett.....	4276.5	3.63109
12 56 22	192 55 27	Pocasset.....	8603.2	3.93466
44 40 17	224 37 26	Mount Hope.....	8459.0	3.92732
325 19 15	145 20 09	Fall River 2.....	3295.8	3.51796
41 20 10	221 17 17	Mount Hope.....	9096.2	3.95886

## TAUNTON RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Fall River spire, 1861.	41 42 06.87	211.9	71 09 15.00	346.8
Fall River tower, 1861.	41 42 00.87	26.7	71 09 25.42	587.7
Fall River derrick.	41 42 19.32	596.0	71 09 56.72	1311.4
Dodge's stable, turret.	41 40 56.33	1737.9	71 10 40.24	930.7
Durfee cupola.	41 42 36.36	1121.8	71 09 04.82	111.4
Swanzey belfry, 1843-61.	41 45 03.22	99.3	71 13 30.90	713.9
Somerset meeting-house, 1843.	41 44 11.54	356.0	71 10 06.89	159.2
Somerset spire, 1861-74.	41 44 11.64	359.1	71 10 06.86	158.5
Somerset spire.	41 46 17.88	551.7	71 07 38.87	897.8
Beacon.	41 42 16.82	518.9	71 10 29.71	686.9
Large chimney with rail on top.	41 42 13.60	419.5	71 09 52.38	1211.0
White barn with square window, cupola.	41 43 28.38	875.6	71 09 43.70	1010.0
Ferry wharf chimney.	41 42 34.30	1058.2	71 10 46.90	1084.2
Mill with conical cupola, chimney.	41 43 06.66	205.5	71 09 22.27	514.8
White church spire.	41 45 08.92	275.5	71 08 32.06	740.7
Steep Brook church.	41 44 30.40	937.8	71 07 46.13	1065.8
Assonet flat topped church, west gable chimney.	41 47 30.26	933.6	71 04 15.24	351.8
Farm-house, white chimney.	41 48 30.40	937.9	71 04 53.04	1224.3
Assonet spire.	41 47 45.95	1417.8	71 04 08.00	184.7
North Dighton.	41 51 14.52	448.0	71 06 39.39	908.7
Meadow.	41 51 11.22	346.2	71 06 11.96	275.9
River.	41 51 36.08	1113.2	71 06 17.02	392.5
Burt.	41 51 28.72	886.1	71 05 49.61	1144.2

## TAUNTON RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
66 40 21	246 36 54	Mount Hope.....	7840. 1	3. 89432
104 42 21	281 39 57	Mattapoisett.....	5117. 4	3. 70905
67 14 17	247 10 57	Mount Hope.....	7545. 7	3. 87770
104 23 01	284 20 44	Mattapoisett.....	4925. 0	3. 69241
60 45 46	240 42 47	Mount Hope.....	7143. 6	3. 85392
176 07 59	356 07 53	Somerset.....	3348. 0	3. 52479
79 54 51	259 52 21	Mount Hope.....	5309. 1	3. 72502
188 03 03	8 03 24	Slade.....	5137. 1	3. 71072
61 38 06	241 34 32	Mount Hope.....	8448. 5	3. 92678
143 23 46	323 23 03	Slade.....	2492. 1	3. 39657
337 25 52	157 27 33	Blackbeard.....	9165. 2	3. 96214
8 30 40	188 30 03	Mount Hope.....	8643. 7	3. 93670
326 32 10	146 33 04	Fall River.....	3412. 1	3. 53302
40 47 20	220 44 27	Mount Hope.....	9183. 1	3. 96299
288 38 52	108 40 13	Calvary.....	2971. 7	3. 47300
40 49 02	220 46 10	Mount Hope 2.....	9173. 8	3. 96255
19 08 10	199 08 03	Bluff.....	763. 1	2. 88258
334 49 03	154 49 22	Ridge.....	1514. 3	3. 18020
190 29 02	10 29 16	Somerset 2.....	2736. 6	3. 43722
346 27 34	166 27 41	City.....	1048. 9	3. 02074
33 52 04	213 51 46	City.....	1108. 1	3. 04460
222 40 14	42 41 25	Calvary.....	3660. 5	3. 56355
14 13 39	194 13 15	City.....	3329. 4	3. 52236
260 26 02	80 27 08	Calvary.....	2312. 6	3. 36410
337 35 05	157 35 24	City.....	1686. 2	3. 22690
241 14 14	61 16 02	Calvary.....	4267. 4	3. 63017
239 26 12	59 27 03	Calvary.....	2073. 1	3. 31663
27 11 38	207 11 00	City.....	2874. 9	3. 45863
347 03 32	167 03 50	Calvary.....	2789. 0	3. 44545
214 49 32	34 50 00	Bluff.....	1713. 4	3. 23386
15 56 36	195 56 23	Calvary.....	1590. 8	3. 20161
136 39 13	316 38 46	Wood.....	1387. 2	3. 14213
136 22 56	316 21 46	Bare Top.....	3520. 4	3. 54658
110 07 57	290 05 38	Richmond Hill.....	5116. 8	3. 70899
114 00 13	293 59 28	Bare Top.....	1702. 9	3. 23119
88 37 07	268 35 13	Richmond Hill.....	3932. 4	3. 59466
75 49 35	255 48 22	Assonet.....	2593. 3	3. 41384
104 24 32	284 22 09	Richmond Hill.....	5132. 7	3. 71034
28 20 12	208 20 04	Telegraph.....	351. 5	2. 72552
337 19 41	157 19 47	High.....	568. 5	2. 75471
99 09 07	279 08 49	North Dighton.....	640. 9	2. 80679
67 32 27	247 32 01	Telegraph.....	957. 7	2. 98124
37 48 21	217 48 06	North Dighton.....	841. 7	2. 92517
351 20 31	171 20 34	Meadow.....	775. 8	2. 88975
43 40 09	223 39 54	Meadow.....	746. 5	2. 87302
109 45 18	289 45 00	River.....	671. 7	2. 82715

## TAUNTON RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Herbert.	41 51 45.41	1401.0	71 05 46.99	1083.8
Carpenter.	41 51 36.08	1113.2	71 05 33.64	775.9
Clark.	41 51 52.70	1625.9	71 05 13.14	303.0
Whitmore.	41 52 12.51	386.0	71 05 31.91	735.9
Birch.	41 52 08.52	262.8	71 05 04.66	107.4
Thrasher.	41 52 22.47	693.2	71 05 16.73	385.8
Hunt.	41 52 38.99	1203.0	71 05 30.23	697.0
Williams.	41 52 43.06	1328.6	71 05 52.70	1215.1
Cupola.	41 52 31.55	973.4	71 05 48.05	1108.0
Schoolhouse.	41 53 14.12	435.6	71 05 38.83	895.2
Hatch.	41 53 01.44	44.4	71 05 13.98	322.3
Taunton Iron Works, chimney	41 52 54.11	1669.4	71 05 38.55	888.8
Johnson.	41 53 20.81	642.0	71 04 43.52	1003.3
French.	41 53 35.60	1098.4	71 05 34.67	799.2
Taunton Unitarian spire	41 54 04.57	141.0	71 05 19.92	459.1
Frederick.	41 53 41.36	1276.2	71 04 27.12	625.2
Mason.	41 54 29.24	902.2	71 04 11.14	256.8
Wilbur.	41 54 40.30	1243.4	71 05 11.67	268.8
Bradford.	41 54 17.32	534.4	71 04 38.04	876.8
Brickyard.	41 54 33.09	1021.0	71 04 45.01	1037.3
Briggs	41 54 56.20	1733.9	71 03 49.46	1139.8
Dean.	41 54 37.32	1151.5	71 04 15.35	353.7
Hall.	41 54 22.37	690.2	71 04 16.29	375.5

## TAUNTON RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
6 42 32	186 42 30	Burt .....	518.4	2.71464
67 26 24	247 26 04	River.	750.1	2.87511
58 21 35	238 21 24	Burt .....	432.8	2.63631
133 03 51	313 03 42	Herbert.	421.4	2.62473
42 41 36	222 41 22	Carpenter .....	697.3	2.84344
73 56 24	253 56 01	Herbert.	812.4	2.90978
324 42 10	144 42 23	Clark .....	748.9	2.87444
22 35 52	202 35 42	Herbert.	905.5	2.95691
101 06 18	281 06 00	Whitmore .....	640.3	2.80639
21 50 45	201 50 39	Clark.	525.7	2.72074
327 07 06	147 07 14	Birch .....	512.5	2.70969
48 44 38	228 44 28	Whitmore.	465.7	2.66807
2 42 27	182 42 26	Whitmore .....	817.7	2.91260
328 34 19	148 34 28	Thrasher.	597.3	2.77619
333 02 13	153 02 27	Whitmore .....	1057.3	3.02418
283 37 30	103 37 45	Hunt.	533.0	2.72671
240 47 46	60 47 58	Hunt .....	470.6	2.67263
163 12 14	343 12 11	Williams.	371.0	2.56937
349 38 09	169 38 15	Hunt .....	1101.8	3.04210
18 27 19	198 27 10	Williams.	1010.2	3.00440
124 19 56	304 19 39	Schoolhouse .....	693.9	2.84126
57 35 11	237 34 45	Williams.	1057.6	3.02432
43 44 19	223 44 10	Williams .....	471.7	2.67363
337 37 55	157 38 01	Hunt.	504.3	2.70270
80 48 42	260 48 05	Schoolhouse .....	1291.9	3.11122
49 36 14	229 35 54	Hatch.	922.2	2.96483
8 14 23	188 14 20	Schoolhouse .....	669.6	2.82583
291 08 53	111 09 27	Johnson.	1264.4	3.10190
20 49 46	200 49 36	French .....	956.3	2.98058
328 07 57	148 08 21	Johnson.	1589.6	3.20129
120 28 55	300 28 20	Unitarian spire .....	1412.2	3.14991
30 48 59	210 48 48	Johnson.	738.0	2.86805
14 00 20	194 00 09	Frederick .....	1522.4	3.18253
64 22 05	244 21 19	Unitarian spire.	1758.6	3.24517
330 32 37	150 33 07	Frederick .....	2088.4	3.31982
9 47 06	189 47 00	Unitarian spire.	1118.7	3.04870
132 27 34	312 27 12	Wilbur .....	1050.5	3.02141
67 50 14	247 49 46	Unitarian spire.	1042.3	3.01798
109 55 26	289 55 08	Wilbur .....	653.6	2.81531
341 43 51	161 43 56	Bradford.	512.3	2.70949
75 29 30	255 28 35	Wilbur .....	1957.0	3.29159
43 01 34	223 01 02	Bradford.	1640.9	3.21509
79 11 03	259 10 43	Brickyard .....	695.9	2.84253
40 17 00	220 16 45	Bradford.	808.9	2.90787
182 42 12	2 42 13	Dean .....	461.7	2.66435
72 43 37	252 43 22	Bradford.	524.9	2.72006

## TAUNTON RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Eddy.	° ' " 41 54 24.83	766.1	° ' " 71 03 58.18	1341.0
King.	41 54 22.66	699.1	71 03 49.49	1140.6
Waterworks.	41 54 11.20	345.6	71 03 50.62	1166.8
Alex.	41 54 07.08	218.5	71 03 34.97	806.0
Martin.	41 54 23.42	722.5	71 03 28.48	656.4
Padelford.	41 54 08.02	247.4	71 03 12.26	282.6
Henry.	41 54 23.12	713.3	71 03 12.80	295.0
Pine.	41 54 12.54	386.8	71 02 58.18	1341.0
Walker.	41 54 23.22	716.4	71 02 57.83	1332.8
Woods.	41 54 19.08	588.7	71 02 44.92	1035.3
Edward.	41 54 10.03	327.9	71 02 46.50	1071.8
Roach.	41 54 08.44	260.3	71 02 27.97	644.5
Grave.	41 54 04.71	145.1	71 02 38.62	890.2
Elisha.	41 53 58.58	1807.3	71 02 23.21	534.8
Cord.	41 53 56.12	1731.4	71 02 36.60	843.6
Kimball.	41 53 48.39	1493.0	71 02 27.11	624.7
Elm.	41 53 51.72	1595.7	71 02 17.50	403.3
Sycamore.	41 53 37.91	1169.7	71 02 20.91	481.9
Rockheap.	41 53 44.16	1362.5	71 02 12.70	292.7
Maplewood.	41 53 27.74	855.8	71 02 12.91	297.5
Stonewall.	41 53 34.08	1051.5	71 02 04.19	96.6
Washburn.	41 53 25.41	784.0	71 01 56.49	1302.3
Squawbetty.	41 53 20.27	625.4	71 02 05.70	131.4

## TAUNTON RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
79 41 52	259 41 40	Hall .....	424. 2	2. 62764
134 14 33	314 14 22	Dean.	552. 2	2. 74213
89 09 53	269 09 30	Hall .....	617. 8	2. 79085
127 11 24	307 11 07	Dean.	748. 0	2. 87393
184 13 03	4 13 04	King .....	354. 6	2. 54978
144 44 11	324 43 54	Dean.	987. 0	2. 99426
109 26 12	289 26 02	Waterworks .....	382. 5	2. 58260
145 10 31	325 10 21	King.	585. 9	2. 76785
87 13 00	267 12 46	King .....	484. 8	2. 68552
16 30 30	196 30 26	Alex.	526. 2	2. 72116
141 49 32	321 49 21	Martin .....	604. 7	2. 78155
86 48 50	266 48 35	Alex.	524. 1	2. 71942
91 28 52	271 28 42	Martin .....	361. 4	2. 55794
358 27 39	178 27 39	Padelford.	466. 2	2. 66860
134 04 48	314 04 38	Henry .....	469. 1	2. 67128
66 42 12	246 42 03	Padelford.	353. 3	2. 54813
89 29 00	269 28 50	Henry .....	345. 0	2. 53783
1 23 19	181 23 19	Pine.	329. 5	2. 51792
113 14 34	293 14 25	Walker .....	323. 9	2. 51035
56 34 44	236 34 35	Pine.	366. 1	2. 56361
146 05 44	326 05 36	Walker .....	468. 0	2. 67026
187 58 22	7 58 23	Woods.	263. 2	2. 42027
98 59 14	278 59 02	Edward .....	432. 3	2. 63582
130 02 37	310 02 26	Woods.	510. 1	2. 70765
135 09 46	315 09 41	Edward .....	257. 4	2. 41069
244 53 41	64 53 48	Roach.	271. 1	2. 43316
118 02 32	298 02 22	Grave .....	402. 3	2. 60458
160 11 07	340 11 04	Roach.	323. 3	2. 50962
256 12 23	76 12 32	Elisha .....	317. 8	2. 50217
207 39 06	27 39 12	Roach.	428. 9	2. 63238
137 30 30	317 30 24	Cord .....	323. 7	2. 51015
195 58 12	15 58 15	Elisha.	327. 1	2. 51465
65 06 39	245 06 33	Kimball .....	244. 3	2. 38793
148 07 26	328 07 22	Elisha.	249. 2	2. 39658
190 27 13	10 27 15	Elm .....	433. 3	2. 63679
156 08 24	336 08 20	Kimball.	353. 5	2. 54839
111 25 45	291 25 35	Kimball .....	357. 0	2. 55264
44 28 02	224 27 57	Sycamore.	270. 3	2. 43179
180 33 26	0 33 26	Rockheap .....	506. 8	2. 70481
149 33 50	329 33 45	Sycamore.	364. 0	2. 56111
107 03 15	287 03 04	Sycamore .....	403. 1	2. 60538
45 46 01	225 45 55	Maplewood.	280. 5	2. 44790
100 45 14	280 45 03	Maplewood .....	385. 2	2. 58571
146 26 17	326 26 12	Stonewall.	321. 1	2. 50658
233 14 00	53 14 06	Washburn .....	265. 0	2. 42318
144 12 05	324 12 00	Maplewood.	284. 2	2. 45356



## TAUNTON RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Jesse.	° / '' 41 53 11.99	370.0	° / '' 71 02 19.21	442.8
Hampden.	41 53 20.15	621.6	71 02 23.86	550.1
Weetamoe.	41 53 08.94	275.9	71 02 30.19	696.0
Sassacus.	41 53 19.88	613.4	71 02 35.87	827.0
Canonicus.	41 53 10.26	316.6	71 02 47.30	1090.5
George.	41 53 17.58	542.4	71 02 48.11	1109.2
Squawbetty nail-factory, chimney.	41 53 12.16	375.2	71 01 54.03	1245.7
Squawbetty, white spire.	41 52 57.37	1770.2	71 01 39.97	921.6
Bryant's Hill.	41 49 39.79	1227.6	71 04 43.71	1008.7
Pigeon Hill.	41 50 58.24	1796.9	70 59 44.57	1028.2

## MASSACHUSETTS AND RHODE ISLAND BOUNDARY.

Beaconpole (Borden), R. I.	42 00 03.257	100.5	71 26 43.159	993.2
Red Brush (C. & G. S. and Borden).	42 01 49.546	1528.7	71 22 23.459	539.6
Oak Hill.	41 54 51.238	1580.8	71 16 43.230	996.3
Mansfield, old Unitarian church.	42 01 23.432	722.9	71 13 04.034	92.8
Wing, R. I.	41 35 23.225	716.7	71 11 10.352	239.8
Paradise Rock, R. I.	41 30 05.511	169.9	71 15 45.504	1055.3
Simmons 2, R. I. 1870.	41 29 32.078	989.7	71 09 34.665	804.1
Little Compton 2, R. I. 1870.	41 31 12.440	383.7	71 11 01.694	39.3
Joe's Rock (Borden).	42 01 52.99	1634.9	71 24 17.24	396.6
Great Rock (C. & G. S. & B.).	41 51 32.36	998.4	71 17 15.47	356.8
King's Rock (Borden).	41 45 22.82	704.0	71 16 17.27	399.0

## TAUNTON RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
230 37 51	50 38 00	Squawbetty .....	402.9	2.60524
196 38 25	16 38 29	Maplewood.	507.3	2.70526
227 07 27	47 07 34	Maplewood .....	344.4	2.53711
336 56 24	156 56 27	Jesse.	273.6	2.43705
202 52 37	22 52 41	Hampden .....	375.3	2.57436
249 36 27	69 36 34	Jesse.	270.0	2.43132
268 15 21	88 15 29	Hampden .....	276.9	2.44234
338 47 35	158 47 39	Weetamoe.	361.8	2.55852
275 52 15	95 52 26	Weetamoe .....	396.6	2.59836
221 36 52	41 36 59	Sassacus.	397.0	2.59875
255 53 41	75 53 49	Sassacus .....	291.2	2.46415
355 15 09	175 15 10	Canonicus.	226.6	2.35523
172 06 01	352 05 59	Washburn .....	412.7	2.61564
132 55 44	312 55 36	Squawbetty.	367.4	2.56515
156 14 33	336 14 22	Washburn .....	945.1	2.97549
139 59 20	319 59 03	Squawbetty.	922.6	2.96501
352 31 05	172 31 50	Copecut .....	11903.6	4.07568
116 28 58	296 23 25	Great Meadow.	12844.3	4.10871
67 11 06	247 05 47	Richmond Hill .....	11989.7	4.07881
100 14 13	280 05 21	Great Meadow.	18692.2	4.27166

## MASSACHUSETTS AND RHODE ISLAND BOUNDARY.

229 16 01.8	49 29 20.0	Blue Hill (Borden) .....	36036.0	4.556737
131 55 21.2	311 37 08.9	Hasnebumskit.	50107.9	4.699906
322 22 16.3	142 28 31.5	Great Meadow .....	21193.4	4.326202
58 30 07.5	238 27 01.6	Beaconpole.	7498.8	3.874993
148 46 29.5	328 42 41.9	Red Brush .....	15097.5	4.178904
307 21 19.9	127 23 47.4	Great Meadow.	6409.0	3.806791
359 51 21.8	179 51 23.0	Great Meadow .....	15991.0	4.203876
22 39 42.8	202 37 16.2	Oak Hill.	13110.8	4.117630
154 08 19.3	334 06 09.2	Mount Hope .....	10386.6	4.016473
82 07 08.5	262 04 23.9	Quaker.	5799.2	3.763371
213 01 28.1	33 04 30.6	Wing .....	11693.8	4.067957
314 11 29.3	134 14 12.9	East Rock.	8001.3	3.903161
96 52 18.7	276 48 13.0	Paradise Rock .....	8663.3	3.937683
32 15 42.2	212 14 20.3	East Rock.	5377.9	3.730613
72 36 29.8	252 33 21.7	Paradise Rock .....	6897.9	3.838715
326 53 33.1	146 54 30.8	Simmons 2.	3696.0	3.567735
317 20 11	137 27 42	Great Meadow .....	22963.8	4.361044
229 58 58	50 10 40	Blue Hill (Borden).	31285.6	4.495344
19 20 33	199 13 48	McSparran .....	42668.3	4.630105
354 56 55	174 58 13	Quaker.	30816.3	4.488780
130 32 00	310 26 51	College Hill .....	14066.5	4.148187
198 13 55	18 16 05	Great Meadow.	14369.1	4.157430

## MASSACHUSETTS AND RHODE ISLAND BOUNDARY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Burnt Swamp (Borden).	° ' " 42 01 08.36	257.9	° ' " 71 22 54.53	1254.6
Bald Hill (Borden).	42 02 44.22	1364.3	71 42 35.59	818.4
Alumpond (Borden).	42 01 14.51	447.7	71 45 45.24	1040.8
Mount Daniel (Borden).	42 01 41.54	1281.6	71 48 10.30	236.9
Northwest corner of Rhode Island (Borden).	42 00 29.15	899.4	71 47 58.92	1355.8
Northeast corner of Connecticut (Borden).	42 01 24.82	765.8	71 48 04.20	96.6
Water tower.	41 59 46.52	1435.3	71 19 21.66	498.5
Hoppin Hill.	41 57 52.71	1626.3	71 20 52.27	1203.6
Foxboro' Baptist church, white spire.	42 03 51.18	1579.1	71 15 05.06	116.3
Foxboro' Orthodox church, dark spire.	42 03 54.65	1686.1	71 15 08.34	191.7
Norton, dark red spire.	41 58 10.49	323.6	71 10 55.37	1274.9
Lone fir tree.	41 54 57.45	1772.5	71 13 43.32	998.3
Attleboro' Catholic church.	41 56 54.14	1670.4	71 17 22.60	520.5
Verification south base (Borden). 1836.	41 50 13.04	402.3	71 21 28.68	661.8
Verification north base (Borden). 1836.	41 54 25.94	800.3	71 21 20.68	476.6
Quicksand 2. 1870.	41 29 56.40	1740.0	71 07 09.16	212.4

## WORCESTER AND MIDDLESEX COUNTIES.

Hasnebumskit (Borden).	42 18 05.114	157.8	71 53 50.811	1163.8
Fay's Mountain (Borden).	42 14 23.786	733.9	71 37 42.540	975.3
Mugget (Borden).	42 08 02.120	65.4	71 57 26.236	602.6
Watatick (Borden).	42 41 48.553	1498.1	71 53 34.870	793.7
Hatchet (Borden).	42 01 39.60	1221.8	72 04 46.74	1075.2

## MASSACHUSETTS AND RHODE ISLAND BOUNDARY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
125 54 18	305 53 23	Joe's Rock.....	2348.4	3.370766
209 20 39	29 21 00	Red Brush.	1458.0	3.163751
151 27 14	331 19 40	Hasnebumskit.....	32365.1	4.510077
249 12 18	69 36 15	Blue Hill (Borden).	52578.1	4.720805
160 22 24	340 16 58	Hasnebumskit.....	33114.0	4.520011
274 40 34	94 53 18	Beaconpole (Borden).	26372.0	4.421144
284 01 11	104 02 48	Alumpond.....	3438.3	3.536350
89 56 35	269 45 28	Hatchet.	22921.2	4.360238
95 26 56	275 15 41	Hatchet.....	23288.5	4.367142
173 17 09	353 17 01	Mount Daniel.	2248.8	3.351960
164 50 30	344 50 26	Mount Daniel.....	534.4	2.72786
275 40 05	95 41 38	Alumpond.	3211.9	3.50676
326 03 18	146 07 32	Great Meadow.....	15665.3	4.19494
89 21 52	269 16 45	Beaconpole.	10578.7	4.02443
238 51 18	58 56 31	Mansfield spire.....	12586.4	4.09990
311 10 58	131 16 12	Great Meadow.	14398.9	4.15833
7 44 06	187 43 00	Oak Hill.....	16811.3	4.22560
69 37 30	249 32 36	Red Brush.	10757.7	4.03172
7 25 57	187 24 54	Oak Hill.....	16907.5	4.22808
68 56 54	248 52 02	Red Brush.	10725.3	4.03041
16 15 22	196 13 57	Great Meadow.....	10455.6	4.01935
52 32 16	232 28 24	Oak Hill.	10099.5	4.00430
346 57 11	166 57 38	Great Meadow.....	4190.3	3.62224
87 22 17	267 20 17	Oak Hill.	4150.5	3.61810
215 35 33	35 38 26	Mansfield spire.....	10220.7	4.00948
321 59 33	142 02 27	Great Meadow.	9747.2	3.98888
169 49 19	349 47 26	Joe's Rock.....	21942.1	4.34128
247 14 49	67 17 38	Great Rock.	6333.1	3.80161
313 25 31	133 28 14	Great Rock.....	7787.7	3.89141
1 21 22	181 21 17	Verification south base.	7804.4	3.89234
113 31 48	293 29 14	Little Compton 2.....	5880.7	3.76943
77 28 34	257 26 58	Simmons.	3457.5	3.53876

## WORCESTER AND MIDDLESEX COUNTIES.

239 36 08.5	60 08 10.2	Holt.....	75169.6	4.876042
278 27 55.5	98 59 30.6	Blue Hill (Borden).	65353.2	4.815267
273 59 30.2	94 20 13.4	Blue Hill (Borden).....	42534.6	4.628742
330 14 03.6	150 21 25.8	Beaconpole (Borden).	30567.4	4.485258
188 18 25.2	8 21 15.0	Wachusett.....	39873.9	4.600688
194 51 10.2	14 53 35.0	Hasnebumskit.	19250.0	4.284430
358 48 56.7	178 49 10.8	Wachusett.....	23078.5	4.363207
275 13 04.5	95 45 02.6	Holt.	64741.2	4.811181
206 17 02	26 24 22	Hasnebumskit.....	33931.2	4.530600
271 34 57	91 47 41	Alumpond.	26272.3	4.419498

## WORCESTER AND MIDDLESEX COUNTIES—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Chandler's Hill (Borden).	42 16 15.20	469.0	71 47 11.43	261.9
Tuft's Hill (Borden).	42 19 01.54	47.5	72 05 04.56	104.4
Hawe's Hill (Borden).	42 27 26.43	815.6	72 07 07.17	163.8
Pepperell (Borden).	42 42 12.64	390.0	71 35 12.59	286.5
Watatick State line (Borden).	42 42 40.93	1263.0	71 53 55.73	1268.2

## MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY.

Saddle Mountain (Borden).	42 38 14.125	435.8	73 09 58.908	1342.1
Becket (Borden).	42 18 06.712	207.1	73 08 46.817	1072.3
Alander Mountain (Borden), New York.	42 05 15.057	464.6	73 30 18.725	430.4
Seymore's Hill (Borden),	42 03 27.856	859.5	73 06 14.729	338.7
Jackson's Hill (Borden).	42 10 20.198	623.2	73 00 50.109	1150.1
Spruce Hill (Borden).	42 40 12.597	388.7	73 04 09.889	225.2
Berlin Mountain (Borden), New York.	42 41 31.596	974.9	73 17 10.504	239.1
Clarksburg (Borden).	42 44 03.571	110.2	73 09 33.739	767.5
Haines, New York.	41 54 37.741	1164.5	73 34 08.072	186.0
Prospect Hill, Connecticut.	41 58 45.109	1391.8	73 23 06.278	144.5
Northwest corner of Massachusetts (Borden).	42 44 45.25	1396.3	73 15 54.17	1232.1
Williamstown Congregational church (Borden).*	42 42 48.76	1504.6	73 12 36.94	840.6
Washington spire.	42 21 57.78	1782.7	73 08 39.78	910.2
Connecticut line (Borden).	42 02 58.78	1813.6	73 29 42.92	986.9
Southwest corner of Massachusetts (Borden).	42 02 59.61	1839.2	73 31 18.72	430.4
Brace Mountain monument, New York.	42 02 39.91	1231.4	73 29 34.88	802.4

\* Modern position different.

## WORCESTER AND MIDDLESEX COUNTIES—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
284 42 59	104 49 22	Fay's Mountain .....	13485.4	4. 129863
42 53 31	222 46 38	Mugget.	20745.5	4. 316924
220 18 51	40 26 50	Wachusett .....	25082.6	4. 399372
276 22 23	96 29 56	Hasnebumskit.	15528.8	4. 191138
91 22 49	271 13 19	Packard .....	19287.6	4. 285278
143 15 31	323 05 53	Mount Grace.	32483.4	4. 511662
46 05 29	225 53 17	Wachusett .....	34279.5	4. 535034
88 24 23	268 11 56	Watatick.	25099.7	4. 399669
271 51 06	92 03 48	Pepperell .....	25575.5	4. 407824
92 13 32	271 56 22	Warwick.	34576.3	4. 538778

## MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY.

244 23 09.6	64 34 50.2	Jilson .....	26068.6	4. 416117
301 16 03.2	121 31 33.9	More's Hill.	36786.1	4. 565684
124 33 50.2	304 24 22.9	Perry's Peak .....	23375.2	4. 368755
212 37 01.2	32 41 24.2	French's Hill.	16555.7	4. 218949
254 51 24.0	74 54 18.0	Bald Peak .....	6180.0	3. 790991
231 06 28.0	51 20 55.7	Becket.	38019.9	4. 580011
100 21 11.6	280 07 57.9	Bald Peak .....	27665.0	4. 441930
172 40 46.2	352 39 04.1	Becket.	27340.2	4. 436801
77 27 05.2	257 10 12.8	Bald Peak .....	35522.1	4. 550499
142 49 56.9	322 44 36.5	Becket.	18073.9	4. 257051
354 30 28.6	174 31 45.3	French's Hill .....	27096.2	4. 432908
65 26 16.3	245 16 19.8	Saddle Mountain (Borden).	8750.1	3. 942012
277 44 10.6	97 52 59.8	Spruce Hill .....	17939.2	4. 253802
301 45 19.7	121 50 12.2	Saddle Mountain (Borden).	11564.5	4. 063128
314 00 24.4	134 04 04.0	Spruce Hill .....	10253.1	4. 010854
3 02 39.1	183 02 22.0	Saddle Mountain (Borden).	10798.1	4. 033346
278 25 49.1	98 39 37.2	Ivy .....	28911.1	4. 461065
207 49 42.6	27 55 09.8	Bald Hill.	24067.6	4. 381432
311 46 39.1	131 53 05.5	Ivy .....	17884.7	4. 252482
63 27 59.2	243 20 36.9	Haines.	17047.9	4. 231672
278 25 05	98 29 23	Clarksburg .....	8748.3	3. 941924
326 08 30	146 12 31	Saddle Mountain (Borden).	14527.9	4. 162204
292 36 43	112 42 27	Spruce Hill .....	12507.8	4. 097180
69 05 53	249 02 48	Berlin Mountain.	6666.1	3. 823870
107 31 58	287 22 25	Perry's Peak .....	20355.8	4. 308689
176 33 56	356 33 03	Greylock.	30179.4	4. 479710
168 55 36	348 55 12	Alander Mountain .....	4284.5	3. 63190
221 28 19	41 30 49	Bald Peak.	7765.5	3. 89017
198 15 36	18 16 16	Alander Mountain .....	4401.0	3. 64355
270 39 05	90 40 09	Connecticut Line.	2203.3	3. 34308
308 58 39	129 02 59	Prospect Hill .....	11508.2	4. 061009
22 56 37	202 53 35	Haines.	16151.5	4. 208214

## MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Iron Bolt.	° ' " 42 02 58.67	1810.2	° ' " 73 29 42.62	980.1
Ryant Bush.	42 03 04.05	125.0	73 28 56.63	1302.3
Ball Peak (or Mount Riga), Connecticut.	42 00 43.33	1336.9	73 27 57.84	1330.8
Corner Stone, New York.	42 02 58.38	1801.2	73 29 15.96	367.0
Pittsfield First Congregational church.	42 26 56.1	1731.1	73 15 09.6	219.3

## CONNECTICUT RIVER VALLEY.

Mount Grace (Borden).	42 41 29.137	899.1	72 21 20.803	473.5
Packard (C. & G. S. & Borden).	42 27 40.636	1253.9	72 21 11.087	253.3
More's Hill (Borden).	42 27 53.041	1636.7	72 47 02.631	60.1
Jilson (Borden).	42 44 18.050	556.9	72 52 45.496	1034.8
Colonel's Mountain (Borden).	42 14 09.353	288.6	72 13 58.354	1338.0
Hilliard's Knob (C. & G. S. & Borden).	42 18 20.230	624.3	72 30 38.374	878.8
Mount Lincoln (C. & G. S. & Borden).	42 21 49.379	1523.6	72 25 24.533	561.4
Proven's Mountain (C. & G. S. & Borden).	42 05 04.486	138.4	72 42 17.176	394.8
Hitchcock (Borden).	42 05 07.392	228.1	72 15 35.428	814.2
Dug Hill (Borden).	42 12 25.341	781.8	72 56 27.159	623.0
Winchell's Mountain (Borden).	42 03 29.137	899.0	72 54 08.006	184.1
Peaked Mountain (C. & G. S. & Borden).	42 02 50.935	1571.5	72 20 26.198	602.5
High Ridge (C. & G. S. & Borden).	42 26 55.123	1700.9	72 43 06.613	151.1
Mount Esther (C. & G. S. & Borden).	42 27 10.190	314.4	72 39 54.642	1248.5
Hatfield North Base (C. & G. S. & Borden). 1832.	42 28 46.150	1424.0	72 36 43.569	995.2
Hatfield South Base (Borden). 1832.	42 22 20.843	643.2	72 36 50.973	1166.2

## MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
310 35 10	130 39 35	Prospect Hill.....	12015.5	4.079741
21 35 58	201 33 00	Haines.	16619.8	4.220626
314 42 34	134 46 28	Prospect Hill.....	11349.8	4.054989
24 41 02	204 37 34	Haines.	17188.3	4.235233
298 29 53	118 33 08	Prospect Hill.....	7637.8	3.882970
37 07 10	217 03 03	Haines.	14139.4	4.150430
37 22 17	217 22 04	Brace Mountain Monument.....	717.0	2.855553
336 39 53	156 40 45	Ball Peak.	4537.5	3.656682
73 35.4	253 30.2	Perry's Peak.....	10944.	4.03916
198 41.5	18 45.0	Saddle Mountain.	22090.	4.34419

## CONNECTICUT RIVER VALLEY.

300 08 27.7	120 27 29.3	Wachusett .....	44545.8	4.648807
268 56 16.8	89 15 06.4	Watatick.	37926.2	4.578939
265 13 52.2	85 32 44.7	Wachusett .....	38434.0	4.584715
179 30 15.6	359 30 09.0	Mount Grace.	25565.5	4.407654
270 28 23.4	90 45 50.9	Packard .....	35450.4	4.549622
234 14 46.6	54 32 09.8	Mount Grace.	43248.9	4.635975
276 45 06.5	97 06 24.9	Mount Grace .....	43202.4	4.635508
345 32 45.2	165 36 37.3	More's Hill.	31382.9	4.496693
225 14 28.7	45 28 27.2	Wachusett .....	40021.7	4.602295
255 09 35.0	75 23 07.2	Hasnebumskit.	28614.2	4.456582
196 29 36.4	16 35 53.0	Mount Grace .....	44707.3	4.650378
128 13 25.3	308 02 21.8	More's Hill.	28623.7	4.456726
48 06 01.3	228 02 29.9	Hilliard's Knob.....	9657.6	3.984869
110 49 51.4	290 35 15.8	More's Hill.	31731.1	4.501485
213 04 51.1	33 12 40.8	Hilliard's Knob .....	29323.7	4.467219
171 13 15.3	351 10 03.3	More's Hill.	42730.1	4.630734
156 26 58.0	336 20 22.1	Mount Lincoln .....	33739.0	4.528132
187 34 55.3	7 36 00.5	Colonel's Mountain.	16869.6	4.227104
252 32 49.3	73 00 10.8	Hilliard's Knob.....	37151.7	4.569979
204 14 47.2	24 21 07.4	More's Hill.	31406.6	4.497021
259 43 42.1	79 51 38.4	Proven's Mountain .....	16604.0	4.220212
169 04 46.2	349 03 12.8	Dug Hill.	16849.9	4.226597
130 24 12.0	310 11 48.1	Mount Tom .....	33385.7	4.523560
153 57 05.2	333 50 14.2	Hilliard's Knob.	31930.0	4.504199
345 54 04.9	165 56 54.3	Mount Tom .....	23677.1	4.374328
312 47 36.5	132 56 00.8	Hilliard's Knob.	23354.8	4.368375
296 22 08.9	116 31 55.7	Mount Lincoln .....	22223.2	4.346806
322 03 21.5	142 09 36.4	Hilliard's Knob.*	20720.6	4.316403
309 34 24.2	129 42 02.3	Mount Lincoln .....	20158.7	4.304463
336 34 37.0	156 38 43.2	Hilliard's Knob.	21042.0	4.323086
273 28 21.7	93 36 04.3	Mount Lincoln .....	15736.8	4.196918
180 48 53.9	0 48 58.9	Hatfield North Base.	11890.1	4.075184



## CONNECTICUT RIVER VALLEY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Rock Rimmon.	42 14 23.142	714.0	72 26 29.666	666.4
Facing Rock.	42 13 08.840	272.8	72 27 34.996	802.7
Feeding Hills.	42 03 52.203	1610.7	72 40 53.754	1235.9
McCarthy.	42 04 13.049	402.6	72 30 17.177	394.9
Brush.	42 09 03.891	120.1	72 39 39.619	909.7
Crafts.	42 12 46.510	1435.1	72 38 20.460	469.3
Shingle Hill.	42 23 23.355	720.6	72 41 59.471	1360.3
Mount Warner.	42 22 48.389	1493.1	72 34 22.124	506.1
North Warner.	42 22 55.991	1727.6	72 34 17.930	410.2
Amherst College chapel.	42 22 15.291	471.8	72 31 06.965	159.4
Dickinson.	42 25 31.485	971.5	72 30 26.662	609.5
Mount Tom (Borden).	42 14 30.80	950.3	72 38 55.12	1263.7
Walnut Hill (Borden).	42 39 06.03	186.1	72 46 29.42	670.2
Bear Mount (Borden).	42 35 13.62	420.3	72 25 32.89	749.9
Warwick (Borden).	42 43 21.57	665.6	72 19 14.26	324.4
Leyden and Guilford (Borden).	42 43 55.29	1706.1	72 38 24.79	563.9
Rattlesnake (Borden).	42 01 59.59	1838.6	72 24 28.62	658.4
Secondary signal (Borden).	42 02 23.04	710.8	72 54 07.82	179.9
Boundary Rock (Borden).	42 01 53.84	1661.1	72 16 18.42	423.8
Connecticut line signal (Borden).	42 01 55.98	1727.2	72 20 46.14	1061.4
Rattle, flag in tree.	42 01 59.08	1822.8	72 24 28.67	659.5
Wigwam.	42 06 26.00	802.2	72 24 45.10	1036.2
Dumpling.	42 10 24.46	754.7	72 20 27.90	640.4

## CONNECTICUT RIVER VALLEY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
338 39 11.1	158 43 14.6	Peaked Mountain.....	22925.3	4.360315
90 51 39.2	270 43 17.7	Mount Tom.	17105.5	4.233136
332 38 27.8	152 43 15.5	Peaked Mountain.....	21458.1	4.331592
99 16 27.0	279 08 49.9	Mount Tom.	15798.5	4.198615
273 43 01.4	93 56 43.7	Peaked Mountain.....	28290.3	4.451638
187 51 49.5	7 53 09.2	Mount Tom.	19890.9	4.298654
280 30 22.1	100 36 58.0	Peaked Mountain.....	13822.8	4.140597
148 05 32.5	327 59 44.9	Mount Tom.	22464.4	4.351496
293 21 39.7	113 34 33.0	Peaked Mountain.....	28894.5	4.460816
241 25 18.5	61 34 09.5	Rock Rimmon.	20640.6	4.314723
306 34 38.0	126 46 38.6	Peaked Mountain.....	30764.4	4.488048
259 34 36.4	79 42 34.5	Rock Rimmon.	16584.6	4.219705
300 53 52.0	121 01 30.8	Hilliard's Knob.....	18180.1	4.259595
345 34 08.7	165 36 12.9	Mount Tom.	16966.1	4.229581
95 55 49.6	275 50 41.3	Shingle Hill.....	10517.5	4.021914
22 10 42.2	202 07 38.5	Mount Tom.	16576.9	4.219502
94 36 55.7	274 31 44.6	Shingle Hill.....	10591.5	4.024958
22 10 48.9	202 07 42.3	Mount Tom.	16830.3	4.226091
354 50 26.6	174 50 45.9	Hilliard's Knob.....	7282.3	3.862266
98 04 10.4	277 56 50.6	Shingle Hill.	15074.5	4.178243
1 09 17.8	181 09 09.9	Hilliard's Knob.....	13309.2	4.124152
98 31 19.2	278 22 46.4	High Ridge.	17560.6	4.244539
273 43 13	93 43 13	Mount Tom.....	1519.5	0.18170
2 05 27	182 05 02	More's Hill.....	20779.0	4.317624
262 31 58	82 48 58	Mount Grace.	34637.2	4.539543
336 49 36	156 52 33	Packard.....	15201.1	4.181875
65 20 01	245 05 29	More's Hill.	32424.9	4.510879
39 42 05	219 40 39	Mount Grace.....	4508.2	3.654000
305 57 45	126 15 21	Wachusett.	44023.0	4.643680
280 51 30	101 03 04	Mount Grace.....	23734.9	4.375388
312 24 16	132 32 59	Bear Mountain.	23836.5	4.377242
103 10 15	282 58 19	Proven's Mountain.....	25223.4	4.401804
164 21 55	344 17 47	Hilliard's Knob.	31424.6	4.497269
170 14 25	350 12 52	Dug Hill.....	18857.3	4.275479
252 58 43	73 06 39	Proven's Mountain.	17082.3	4.232546
107 12 20	287 09 34	Peaked Mountain.....	5965.5	3.775644
189 23 30	9 23 59	Hitchcock.	6053.7	3.782023
230 23 30	50 26 58	Hitchcock.....	9269.4	3.967053
270 35 55	90 38 54	Boundary Rock.	6158.9	3.789505
117 19 00	297 15 07	McCarthy.....	9017.4	3.95508
153 58 09	74 00 52	Peaked Mountain.	5801.6	3.76355
170 48 09	350 46 59	Rock Rimmon.....	14913.9	4.17359
318 05 16	138 08 09	Peaked Mountain.	8913.3	3.95004
131 40 01	311 35 58	Rock Rimmon.....	11085.1	4.04474
359 50 24	179 50 25	Peaked Mountain.	13992.7	4.14590

## CONNECTICUT RIVER VALLEY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Fish Rock.	42 10 35.96	1109.5	72 47 57.78	1326.1
White, flag in tree.	42 12 02.27	70.0	72 29 47.53	1090.5
Longmeadow, Congregational church spire.	42 03 00.83	25.6	72 34 56.24	1293.3
East Longmeadow, Congregational church spire.	42 03 51.49	1588.7	72 30 45.62	1048.9
Feeding Hills, Congregational church spire.	42 04 04.15	128.0	72 40 45.48	1045.6
Feeding Hills, Methodist church spire.	42 03 58.94	1818.5	72 40 44.54	1024.0
Holland's (H.) house, chimney.	42 05 05.04	155.5	72 42 14.89	342.2
Springfield, water-shops tower.	42 05 51.94	1602.6	72 33 50.44	1159.1
Springfield, Florence street Methodist church spire.	42 06 01.11	34.2	72 34 03.72	85.5
Springfield, Hope Congregational church tower.	42 06 38.69	1193.8	72 33 55.63	1278.1
Springfield, State street Methodist church.	42 06 19.18	591.8	72 34 53.36	1226.1
Springfield Arsenal, clock tower.	42 06 26.48	817.0	72 34 54.70	1256.8
Springfield, South Congregational church tower.	42 06 08.04	248.1	72 35 00.10	2.3
Springfield, First Baptist church spire.	42 06 10.88	335.7	72 35 04.19	96.3
Springfield, North Congregational church spire.	42 06 21.77	671.7	72 35 13.45	309.0
Springfield, court-house, tower.	42 06 01.48	45.7	72 35 21.02	483.0
Springfield, Saint Michael's church spire.	42 06 15.20	469.0	72 35 05.10	117.2
Springfield, Saint Joseph's Catholic church spire.	42 06 06.63	204.6	72 35 10.64	244.5
West Springfield, Park street Congregational church spire.	42 06 23.52	725.7	73 37 11.54	265.1
West Springfield, First Congregational church spire.	42 06 52.18	1610.0	72 37 31.94	733.8
Chicopee, Catholic church spire.	42 08 40.26	1242.2	72 36 20.25	465.0
Chicopee, town hall spire.	42 08 54.65	1686.2	72 36 25.94	595.6
Chicopee, French Catholic church spire.	42 08 49.11	1515.2	72 35 34.15	784.1

## CONNECTICUT RIVER VALLEY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
239 44 56	59 51 01	Mount Tom.....	14404.6	4.15850
295 46 19	115 58 11	McCarthy.	27075.7	4.43258
110 06 02	289 59 55	Mount Tom.....	13367.5	4.12605
235 56 32	55 58 01	Facing Rock.	3668.6	3.56450
208 20 08	28 25 04	Facing Rock.....	21322.6	4.32884
250 49 33	70 52 40	McCarthy.	6791.9	3.83199
90 08 46	270 01 59	Feeding Hills.....	13981.7	4.14556
150 22 34	330 17 06	Mount Tom.	22702.3	4.35607
27 18 57	207 18 51	Feeding Hills.....	414.9	2.61793
268 51 09	88 58 10	McCarthy.	14447.1	4.15978
45 33 07	225 33 01	Feeding Hills.....	297.0	2.47277
268 12 47	88 19 48	McCarthy.	14429.8	4.15926
205 48 47	25 50 31	Brush.....	8187.3	3.91314
320 18 16	140 19 10	Feeding Hills.	2920.6	3.46547
69 14 56	249 10 12	Feeding Hills.....	10407.8	4.01736
126 28 31	306 24 37	Brush.	9970.3	3.99871
67 09 25	247 04 50	Feeding Hills.....	10229.4	4.00985
126 11 46	306 08 01	Brush.	9556.7	3.98031
311 48 34	131 51 00	McCarthy.....	6738.0	3.82853
61 54 44	241 50 04	Feeding Hills.	10896.8	4.03730
301 29 11	121 32 16	McCarthy.....	7445.8	3.87191
61 20 01	241 15 59	Feeding Hills.	9443.4	3.97513
126 36 16	306 33 05	Brush.....	8149.3	3.91112
159 45 30	339 42 49	Mount Tom.	15928.9	4.20219
298 35 34	118 38 42	McCarthy.....	7407.5	3.86967
62 45 25	242 41 28	Feeding Hills.	9145.8	3.96122
61 59 46	241 55 52	Feeding Hills.....	9102.9	3.95918
130 10 57	310 07 53	Brush.	8277.7	3.91791
59 29 28	239 25 40	Feeding Hills.....	9081.6	3.95816
160 08 06	340 06 00	Crafts.	12623.5	4.10118
62 29 05	242 25 22	Feeding Hills.....	8625.8	3.93580
161 46 20	341 44 19	Crafts.	13158.3	4.1.920
61 11 42	241 07 49	Feeding Hills.....	9148.1	3.96133
129 33 38	309 40 34	Brush.	8175.8	3.91253
297 25 40	117 28 57	McCarthy.....	7601.0	3.88087
62 17 27	242 13 37	Feeding Hills.	8910.7	3.94991
171 01 46	351 00 36	Mount Tom.....	15221.2	4.18245
172 22 48	352 22 02	Crafts.	11922.3	4.07636
39 53 23	219 51 08	Feeding Hills.....	7235.2	3.85945
144 11 52	324 10 26	Brush.	5011.3	3.69995
99 04 06	279 01 52	Brush.....	4635.5	3.66610
235 26 36	55 32 28	Facing Rock.	14627.8	4.16518
33 25 33	213 22 34	Feeding Hills.....	11177.9	4.04836
93 41 04	273 38 54	Brush.	4456.4	3.64898
94 38 54	274 36 09	Brush.....	5654.7	3.75241
152 29 31	332 27 40	Crafts.	8259.6	3.91696

## CONNECTICUT RIVER VALLEY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Chicopee, skating rink spire.	42 08 50.25	1550.4	72 36 36.77	844.3
Chicopee Falls, Catholic church spire.	42 09 42.82	1321.2	72 34 51.06	1172.2
Chicopee Falls, Congregational church spire.	42 09 25.06	773.2	72 34 51.70	1186.9
Chicopee Falls, New Baptist church spire.	42 09 26.08	804.7	72 34 54.10	1242.0
Chicopee Falls, Methodist church spire.	42 09 25.50	786.8	72 35 00.37	8.5
Holyoke, St. Jerome's Catholic church spire.	42 12 34.10	1052.1	72 36 31.76	728.6
Holyoke, Second Congregational church tower.	42 12 18.36	566.5	72 36 39.50	906.2
Holyoke, Second Baptist church tower.	42 12 24.78	764.6	72 36 48.58	1114.4
Holyoke, French Catholic church spire.	42 11 56.88	1755.0	72 36 23.26	533.7
Holyoke, engine-house tower.	42 12 46.50	1434.7	72 37 31.98	733.6
Holyoke, First Congregational church belfry.	42 12 41.16	1270.0	72 37 49.36	1132.3
Holyoke, Windsor Hotel tower.	42 12 23.07	711.8	72 36 22.72	521.2
Holyoke, city hall tower.	42 12 24.32	750.4	72 36 28.10	644.6
Baptistville, First Baptist church spire.	42 11 42.04	1297.1	72 37 49.05	1125.4
East Bench Mark.	42 12 53.96	1664.9	72 36 10.22	234.4
East Tidal Bench Mark.	42 12 53.95	1664.6	72 36 10.40	238.5
West Bench Mark.	42 12 44.22	1364.4	72 36 14.10	323.4
South Hadley Falls, Catholic church spire.	42 13 13.03	402.0	72 36 05.58	128.0
South Hadley Falls, Methodist church spire.	42 13 00.92	28.4	72 35 56.42	1294.1
South Hadley Falls, Congregational church spire.	42 12 58.25	1797.2	72 35 56.56	1297.3
South Hadley Female Seminary observatory.	42 15 21.78	672.0	72 34 40.88	937.1
South Hadley, Congregational church spire.	42 15 31.59	974.7	72 34 31.26	716.5
Wilbraham, Rich Hall tower.	42 07 27.68	854.0	72 25 55.10	1265.6

## CONNECTICUT RIVER VALLEY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
95 44 26	275 42 23	Brush.....	4219.4	3.62525
161 55 45	341 54 36	Crafts.....	7668.3	3.88470
79 44 58	259 41 44	Brush.....	6732.9	3.82820
139 43 38	319 41 17	Crafts.....	7430.4	3.87101
84 23 08	264 19 55	Brush.....	6642.6	3.82234
142 23 44	322 21 24	Crafts.....	7847.8	3.89475
142 34 33	322 32 14	Crafts.....	7789.1	3.89149
235 39 35	55 44 30	Facing Rock.	22197.2	4.08626
143 30 17	323 28 03	Crafts.....	7716.8	3.88744
235 58 02	56 03 01	Facing Rock. •	12326.2	4.09083
98 44 06	278 42 53	Crafts.....	2522.7	3.40186
137 37 29	317 35 53	Mount Tom.	4875.3	3.68800
110 33 59	290 32 51	Crafts.....	2473.4	3.39329
142 44 57	322 43 26	Mount Tom.	5135.1	3.71055
107 38 49	287 37 47	Crafts.....	2211.6	3.34471
143 17 13	323 15 48	Mount Tom.	4851.2	3.68585
119 40 28	299 39 09	Crafts.....	3094.0	3.49052
143 46 12	323 44 30	Mount Tom.	5889.0	3.77004
90 01 30	270 00 57	Crafts.....	1112.1	3.04616
149 22 51	329 21 55	Mount Tom.	3740.3	3.57291
103 01 32	283 01 11	Crafts.....	732.3	2.86470
155 59 52	335 59 08	Mount Tom.	3703.4	3.56860
254 43 22	74 50 01	Rock Rimmon.....	14109.8	4.14952
263 17 50	83 23 44	Facing Rock.	12186.8	4.08589
104 52 52	284 51 37	Crafts.....	2666.9	3.42600
139 11 47	319 10 08	Mount Tom.	5156.6	3.71236
160 05 32	340 05 11	Crafts.....	2115.8	3.32548
259 10 44	79 17 36	Facing Rock.	14338.7	4.15651
24 09 27	204 09 15	Holyoke City Hall.....	1002.3	3.00098
128 20 16	308 18 25	Mount Tom.	4818.8	3.68294
85 36 52	265 35 25	Crafts.....	2992.1	3.47597
128 22 27	308 20 36	Mount Tom.	4815.4	3.68263
131 42 45	311 40 57	Mount Tom.....	4943.7	3.69405
196 32 57	16 33 00	East Bench Mark.	313.5	2.49621
75 12 24	255 10 53	Crafts.....	3200.7	3.50525
121 42 23	301 40 29	Mount Tom.	4567.1	3.65964
82 21 08	262 19 31	Crafts.....	3333.7	3.52293
124 06 50	304 04 50	Mount Tom.	4947.0	3.69434
83 45 06	263 43 29	Crafts.....	3220.5	3.51221
124 55 03	304 53 03	Mount Tom.	4991.0	3.69819
46 26 38	226 24 11	Crafts.....	6949.8	3.84197
74 55 02	254 52 11	Mount Tom.	6035.6	3.78072
45 55 11	225 52 37	Crafts.....	7319.0	3.86445
72 47 38	252 44 41	Mount Tom.	6331.7	3.80152
45 06 14	225 03 19	McCarthy.....	8504.7	3.92966
98 59 09	278 49 57	Brush.....	19166.8	4.28255

## CONNECTICUT RIVER VALLEY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Wilbraham, Congregational church spire.	42 07 16.48	508.5	72 25 54.87	1260.4
Indian Orchard, church spire.	42 09 32.02	988.0	72 30 07.04	161.6
Indian Orchard, French Catholic church spire.	42 09 33.30	1027.4	72 29 59.96	1376.5
Indian Orchard, Congregational church tower.	42 09 24.98	770.7	72 30 25.45	584.3
Jenksville church tower (1).	42 09 31.91	984.6	72 29 06.70	153.8
Jenksville church tower (2).	42 09 30.19	931.5	72 28 58.94	1353.1
Wilson's (Foster) house, tower.	42 12 50.94	1571.7	72 38 08.34	191.3
Ludlow, Congregational church spire.	42 11 30.41	938.3	72 27 37.86	868.7
Ludlow, Methodist church spire.	42 11 29.10	897.9	72 27 09.72	223.0
Palmer, Universalist church spire.	42 09 28.06	865.8	72 19 35.91	824.4
Three Rivers, French Catholic church spire.	42 11 00.72	22.2	72 21 21.30	488.8
Granby, Congregational church spire.	42 15 22.87	705.6	72 31 04.12	94.4
Belchertown, High School tower.	42 16 37.90	1169.4	72 24 11.95	273.8
Belchertown, Baptist church tower.	42 16 40.81	1259.2	72 24 04.66	106.8
Belchertown, First Congregational church spire.	42 16 42.68	1316.9	72 24 05.98	137.0
Belchertown, Methodist church tower.	42 16 42.12	1299.6	72 24 10.26	235.1
Easthampton, Williston Mill tower.	42 16 27.69	854.4	72 39 33.42	765.9
Easthampton, Methodist church tower.	42 16 15.79	487.2	72 40 22.28	510.6
Easthampton, Williston Seminary gymnasium tower.	42 16 13.85	427.4	72 40 16.00	366.7
Easthampton, First Congregational church spire.	42 16 20.74	639.9	72 40 17.24	395.1
Easthampton, Payson Congregational church spire.	42 16 12.02	370.9	72 40 22.78	522.0
Easthampton, town hall tower.	42 16 16.66	514.1	72 40 21.85	500.7
Easthampton, Williston, Knight & Co.'s chimney.	42 16 00.90	27.8	72 40 11.40	261.3

## CONNECTICUT RIVER VALLEY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
100 00 08	279 50 55	Brush.....	19228.7	4.28395
168 04 21	348 03 14	Facing Rock.....	11112.2	4.04580
127 19 10	307 13 15	Mount Tom.....	15222.6	4.18249
207 31 44	27 33 26	Facing Rock.....	7544.8	3.87765
126 50 08	306 44 09	Mount Tom.....	15327.8	4.18548
266 33 18	26 34 55	Facing Rock.....	7436.0	3.87134
119 44 45	299 39 26	Crafts.....	12549.3	4.09862
209 30 18	29 32 13	Facing Rock.....	7937.8	3.89970
115 20 33	295 14 21	Crafts.....	14054.3	4.14781
197 26 40	17 27 41	Facing Rock.....	7016.2	3.84610
115 13 46	295 07 29	Crafts.....	14238.4	4.15346
195 55 31	15 56 27	Facing Rock.....	7015.8	3.84608
63 45 50	243 45 42	Crafts.....	310.0	2.49132
160 49 44	340 49 12	Mount Tom.....	3262.1	3.51350
181 13 57	1 13 59	Facing Rock.....	3037.7	3.48254
109 46 36	289 39 01	Mount Tom.....	16499.9	4.21748
109 10 42	289 02 49	Mount Tom.....	17121.8	4.23355
169 19 54	349 19 37	Facing Rock.....	3131.5	3.49575
5 23 32	185 22 58	Peaked Mount.....	12306.9	4.09015
145 33 27	325 32 52	Dumpling.....	2109.8	3.32424
312 22 58	132 23 34	Dumpling.....	1659.4	3.21995
131 31 45	311 28 18	Rock Rimmon.....	9425.8	3.97432
310 45 31	130 47 52	Facing Rock.....	6331.8	3.80153
45 22 21	225 16 35	Brush.....	16631.1	4.22092
79 07 04	258 57 10	Mount Tom.....	20618.6	4.31426
130 06 58	310 00 11	North Warner.....	18126.8	4.25832
69 51 12	249 41 38	Crafts.....	20909.8	4.32035
37 56 33	217 54 56	Rock Rimmon.....	5385.3	3.73121
78 47 27	258 37 29	Mount Tom.....	20780.7	4.31766
136 49 58	316 45 15	College Chapel.....	14079.9	4.14860
78 47 04	258 37 08	Mount Tom.....	20681.4	4.31553
137 10 30	317 05 49	College Chapel.....	14025.2	4.14691
227 11 24	47 17 05	College Chapel.....	15796.1	4.19855
346 17 23	166 17 49	Mount Tom.....	3712.4	3.56966
214 12 44	34 16 46	Mount Warner.....	14654.1	4.46596
328 18 27	148 19 26	Mount Tom.....	3806.9	3.58057
228 22 26	48 28 36	College Chapel.....	16805.8	4.22546
329 43 44	149 44 38	Mount Tom.....	3681.4	3.56601
214 10 30	34 14 29	Mount Warner.....	14463.1	4.16026
330 56 39	150 57 34	Mount Tom.....	3879.9	3.58882
213 59 41	34 03 44	Mount Warner.....	14757.1	4.16900
327 12 57	147 13 56	Mount Tom.....	3714.6	3.56991
214 14 23	34 18 25	Mount Warner.....	14626.5	4.16514
328 38 47	148 39 45	Mount Tom.....	3824.6	3.58259
212 25 41	32 29 36	Mount Warner.....	14901.2	4.17322
327 48 01	147 48 52	Mount Tom.....	3285.1	3.51655



## CONNECTICUT RIVER VALLEY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
West Hampton, Congregational church spire.	42 18 16.57	511.3	72 46 32.39	741.9
Northampton, First Congregational church spire.	42 19 09.25	285.4	72 37 53.14	1216.9
Northampton, Second Congregational church spire.	42 19 04.62	142.6	72 38 04.32	98.9
Northampton, Catholic church tower.	42 19 38.61	1191.3	72 38 02.98	68.2
Northampton, lunatic asylum tower.	42 18 52.16	1609.4	72 38 51.00	1168.0
Northampton, Methodist church spire.	42 19 10.72	330.8	72 37 59.58	1364.3
Northampton, Episcopal church spire.	42 19 16.38	505.4	72 37 42.57	974.8
Northampton, Round Hill flagstaff.	42 19 27.53	849.4	72 38 22.38	512.4
Nonotuck Hotel tower.	42 16 47.86	1476.7	72 37 15.19	348.1
Connecticut River Lumber Company's chimney.	42 17 29.65	914.8	72 37 14.30	327.6
Mount Holyoke Hotel flagstaff.	42 18 02.12	65.4	72 35 17.62	403.6
South Amherst, Monson's barn cupola.	42 20 36.78	1134.9	72 30 24.64	564.0
South Amherst, church spire.	42 20 25.45	785.3	72 30 13.94	319.1
Smith's (Edwin) barn, cupola.	42 20 56.34	1738.4	72 33 10.66	244.0
Hadley, First Congregational church spire.	42 20 30.88	952.8	72 35 20.81	476.4
Hadley, Second Congregational church spire.	42 20 33.90	1046.0	72 35 47.72	1092.3
New Braintree, Congregational church spire.	42 19 01.16	35.8	72 07 35.90	822.1
Florence, engine-house tower.	42 20 04.52	139.5	72 40 19.43	444.8
Florence, Catholic church spire.	42 19 56.78	1752.0	72 40 07.03	160.9
Florence, Congregational church spire.	42 19 54.16	1671.1	72 40 30.00	686.8
Florence, school-house tower.	42 19 51.98	1603.8	72 40 33.41	764.9
Florence, Methodist church spire.	42 20 07.18	221.5	72 40 25.22	577.4
Florence, Cosmian Hall clock tower.	42 20 09.26	285.7	72 40 26.55	607.8

## CONNECTICUT RIVER VALLEY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
303 34 06	123 39 14	Mount Tom .....	12583.5	4.09980
308 19 17	128 36 49	Peaked Mount.	45910.3	4.66191
144 18 16	324 15 30	Shingle Hill .....	9657.2	3.98485
215 31 06	35 33 28	Mount Warner.	8309.4	3.91957
216 21 12	36 23 42	Mount Warner .....	8575.3	3.93325
7 50 24	187 49 50	Mount Tom.	8528.1	3.93085
220 46 46	40 49 15	Mount Warner .....	7735.7	3.88850
142 03 10	322 00 31	Shingle Hill.	8796.7	3.94432
239 24 52	59 30 05	College Chapel .....	12333.4	4.09108
0 39 28	180 39 25	Mount Tom.	8064.7	3.90659
144 51 55	324 49 14	Shingle Hill .....	9534.5	3.97930
238 52 18	58 56 56	College Chapel.	11029.4	4.04255
142 22 22	322 19 29	Shingle Hill .....	9625.0	3.98340
215 01 27	35 03 42	Mount Warner.	7290.1	3.90255
221 33 38	41 36 20	Mount Warner .....	8285.0	3.91831
242 30 51	62 35 44	College Chapel.	11230.5	4.05040
151 57 16	331 54 05	Shingle Hill .....	13829.9	4.14082
199 35 25	19 37 21	Mount Warner.	11808.6	4.07220
201 49 39	21 51 35	Mount Warner .....	10596.2	4.02515
223 37 30	43 41 37	College Chapel.	12181.8	4.08571
137 10 32	317 06 02	Shingle Hill .....	13522.3	4.13104
188 10 44	8 11 21	Mount Warner.	8923.8	3.95055
126 47 27	306 44 47	Mount Warner .....	6784.1	3.83149
162 19 52	342 19 24	College Chapel.	3190.1	3.50380
127 51 18	307 48 31	Mount Warner .....	7190.8	3.85678
160 18 31	340 17 55	College Chapel.	3599.6	3.55626
110 36 02	290 30 06	Shingle Hill .....	12922.3	4.11134
154 41 24	334 40 36	Mount Warner.	3824.8	3.58261
120 17 45	300 13 16	Shingle Hill .....	10560.9	4.02370
197 33 25	17 34 04	Mount Warner.	4450.3	3.64839
121 36 46	301 32 36	Shingle Hill .....	9984.8	3.99934
205 15 25	25 16 23	Mount Warner.	4589.0	3.66172
30 38 05	210 29 27	Peaked Mountain .....	34764.8	4.54114
71 49 19	251 36 37	Rock Rimmon.	27346.4	4.43690
159 32 42	339 31 35	Shingle Hill .....	6548.2	3.81612
252 15 01	72 21 13	College Chapel.	13272.7	4.12296
236 06 48	56 10 40	Mount Warner .....	9504.7	3.97794
350 41 06	170 41 54	Mount Tom.	10192.5	4.00828
237 24 20	57 28 28	Mount Warner .....	9989.6	3.99955
347 41 26	167 42 30	Mount Tom.	10211.5	4.00909
347 10 50	167 11 56	Mount Tom .....	10167.7	4.00701
163 12 19	343 11 21	Shingle Hill.	6813.0	3.83334
160 23 43	340 22 40	Shingle Hill .....	6425.8	3.80793
239 03 37	59 07 41	Mount Warner.	9685.0	3.98610
160 27 36	340 26 34	Shingle Hill .....	6354.9	3.80311
253 03 30	73 09 47	College Chapel.	13384.7	4.12661

## CONNECTICUT RIVER VALLEY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Florence Manufacturing Company's mill tower.	42 19 53.57	1652.9	72 40 44.64	1022.0
Hatfield, Congregational church spire.	42 22 13.68	422.1	72 35 50.97	1166.2
Hatfield, Smith Academy tower.	42 22 15.68	483.8	72 35 44.70	1022.8
North Hadley, Congregational church spire.	42 23 19.71	608.2	72 34 52.02	1189.9
Haydensville, Catholic church spire.	42 22 22.87	705.7	72 41 53.70	1228.6
Haydensville, Congregational church spire.	42 21 15.34	473.3	72 41 39.08	894.4
Amherst, College Hall.	42 22 22.02	679.4	72 31 14.42	329.9
Amherst, Williston Hall tower.	42 22 17.76	548.0	72 31 06.59	150.8
Amherst, Walker Hall tower.	42 22 18.21	561.9	72 31 02.82	64.5
Amherst, Episcopal church spire.	42 22 29.76	918.2	72 31 09.06	207.3
Amherst, Congregational church spire.	42 22 32.07	989.5	72 31 00.60	13.7
Amherst Agricultural College drill-hall tower.	42 23 17.06	526.4	72 31 43.56	996.4
Amherst Agricultural College flagstaff.	42 23 21.69	669.3	72 31 42.64	975.4
Amherst Agricultural College belfry.	42 23 26.31	811.8	72 31 46.50	1063.6
Amherst, Lawrence observatory equatorial cover, center.	42 22 17.06	526.4	72 31 10.05	229.9
Amherst City, Methodist church tower.	42 24 50.34	1553.2	72 30 32.79	749.7
Pelham church spire.	42 23 32.30	996.6	72 24 17.34	396.6
North Amherst, Congregational church spire.	42 24 36.74	1133.6	72 31 52.29	1195.7
Dickinson's (Charles R.) barn cupola.	42 25 23.87	736.5	72 31 49.77	1137.8
Deacon Elihu's barn tower.	42 26 06.46	199.3	72 35 22.80	521.1
Whately, Congregational church spire	42 26 17.07	526.7	72 38 07.34	167.8
Cot. way Township, southeast corner.	42 27 30.25	933.4	72 39 28.34	647.5
Chestnut Hill.	42 24 34.29	1058.0	72 39 40.12	917.4

## CONNECTICUT RIVER VALLEY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
345 50 28	165 51 42	Mount Tom.....	10270. 7	4. 01160
165 11 14	345 10 24	Shingle Hill.	6695. 8	3. 82580
242 12 25	62 13 25	Mount Warner .....	2297. 6	3. 36128
131 07 17	311 02 23	High Ridge.	13215. 4	4. 12108
147 51 26	327 48 37	Mount Esther .....	10735. 0	4. 03080
241 52 50	61 53 46	Mount Warner.	2141. 9	3. 33080
135 49 00	315 45 36	Mount Esther .....	9921. 8	3. 99659
236 09 06	56 12 05	Dickinson.	7304. 5	3. 86359
175 57 26	355 57 22	Shingle Hill .....	1870. 9	3. 27204
344 17 34	164 19 34	Mount Tom.	15129. 3	4. 17982
192 17 42	12 18 52	Mount Esther .....	11207. 0	4. 04949
343 13 55	163 15 45	Mount Tom.	13035. 3	4. 11512
36 00 30	215 55 20	Mount Tom.....	17963. 9	4. 25440
100 44 44	280 42 38	Mount Warner.	4370. 8	3. 64056
6 21 56	186 21 56	College Chapel .....	76. 6	1. 88429
101 56 49	281 54 37	Mount Warner.	4572. 3	3. 66013
101 33 34	281 31 19	Mount Warner .....	4653. 9	3. 66782
187 53 30	7 53 54	Dickinson.	6020. 6	3. 77964
353 51 42	173 51 43	College Chapel .....	449. 1	2. 65232
97 25 58	277 23 48	Mount Warner.	4454. 0	3. 64875
15 43 02	195 42 58	College Chapel .....	537. 7	2. 73054
96 15 14	276 12 58	Mount Warner.	4637. 6	3. 66629
31 21 50	211 17 00	Mount Tom.....	19008. 2	4. 27894
79 35 20	259 33 36	North Warner.	3590. 7	3. 55518
338 16 30	158 16 54	College Chapel .....	2205. 6	3. 34352
77 25 42	257 23 57	North Warner.	3639. 7	3. 56107
337 33 55	157 34 22	College Chapel .....	2370. 8	3. 37489
74 53 59	254 52 17	North Warner.	3587. 9	3. 55484
105 37 40	285 35 34	North Warner .....	4463. 1	3. 64964
189 23 18	9 23 47	Dickinson.	6080. 8	3. 78396
55 36 00	235 33 28	North Warner .....	6242. 1	3. 79533
186 18 04	6 18 08	Dickinson.	1277. 1	3. 10624
50 20 48	230 10 58	Mount Tom.....	26137. 3	4. 41726
85 23 33	265 16 47	North Warner.	13784. 1	4. 13938
27 24 42	207 19 58	Mount Tom.....	21053. 8	4. 32333
105 32 45	285 25 10	High Ridge.	15995. 2	4. 20399
36 36 34	216 34 54	North Warner .....	5683. 3	3. 75460
262 56 42	82 57 38	Dickinson.	1914. 5	3. 28206
61 00 49	240 56 22	Shingle Hill .....	10372. 7	4. 01589
107 35 36	287 32 33	Mount Esther.	6516. 3	3. 81400
277 33 55	97 39 05	Dickinson .....	10624. 0	4. 02629
319 45 54	139 48 29	North Warner.	8124. 7	3. 90981
319 59 10	140 02 39	North Warner .....	11044. 3	4. 04314
44 09 32	224 09 14	Mount Esther.	862. 5	2. 93578
55 31 54	235 30 20	Shingle Hill .....	3866. 2	3. 58728
132 39 07	312 36 48	High Ridge.	6416. 2	3. 80728

## CONNECTICUT RIVER VALLEY—Continued.

Station.	Latitude. ° / "	Seconds in metres.	Longitude. ° / "	Seconds in metres.
Battlecock.	42 23 02.75	84.8	72 46 25.47	582.7
Leverett, Congregational church spire.	42 27 07.80	240.7	72 30 06.90	157.7
Sunderland, school-house tower.	42 28 02.32	71.6	72 34 44.74	1022.1
Sunderland, Congregational church spire.	42 27 57.91	1786.9	72 34 49.70	1135.4
Mount Toby.	42 29 16.32	503.6	72 32 16.28	371.8
Shutesbury, Congregational church spire.	42 27 11.85	365.6	72 24 37.34	853.2
Shutesbury, Baptist church spire.	42 27 10.31	318.1	72 24 36.46	833.1
Shutesbury, house, chimney.	42 27 42.20	1302.1	72 24 41.61	950.7
Boyden's (Col.) barn cupola.	42 28 58.00	1789.6	72 36 51.15	1168.3
South Deerfield, Congregational church spire.	42 28 44.71	1379.6	72 36 27.16	620.4
Sugarloaf Hotel, south chimney.	42 28 13.00	401.1	72 35 32.98	753.4
Sugarloaf Hotel, north chimney.	42 28 13.30	410.4	72 35 33.08	755.7

## CONNECTICUT RIVER VALLEY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
264 00 39	84 03 38	Shingle Hill -----	6118. 0	3. 78661
326 48 44	146 53 48	Mount Tom.	18865. 6	4. 27567
36 28 33	216 25 44	North Warner -----	9659. 6	3. 98496
88 48 56	268 40 10	High Ridge.	17821. 7	4. 25095
356 17 10	176 17 28	North Warner -----	9472. 0	3. 97644
79 47 51	259 42 12	High Ridge.	11653. 1	4. 06644
355 32 19	175 32 40	North Warner -----	9344. 2	3. 97054
78 05 46	258 02 20	Mount Esther.	7121. 1	3. 85255
13 20 26	193 19 04	North Warner -----	12060. 4	4. 08136
69 39 19	249 34 10	Mount Esther.	11170. 7	4. 04808
73 36 47	253 25 04	Shingle Hill -----	24846. 2	4. 39526
89 56 46	269 46 27	Mount Esther.	20960. 4	4. 32140
73 43 54	253 32 11	Shingle Hill -----	24853. 1	4. 39538
90 04 36	269 54 16	Mount Esther.	20980. 2	4. 32181
56 13 19	236 06 50	North Warner -----	15861. 3	4. 20034
71 29 35	251 17 55	Shingle Hill.	25034. 6	4. 39854
51 34 43	231 32 39	Mount Esther -----	5351. 4	3. 72847
66 11 14	246 07 00	High Ridge.	9378. 4	3. 97213
344 38 12	164 39 39	North Warner -----	11158. 1	4. 04759
58 25 02	238 22 42	Mount Esther.	5565. 7	3. 74552
350 02 31	170 03 22	North Warner -----	9930. 7	3. 99698
76 59 25	256 54 19	High Ridge.	10639. 5	4. 02692
44 40 11	224 35 50	Shingle Hill -----	12571. 6	4. 09939
76 56 24	256 51 18	High Ridge.	10639. 5	4. 02692

*Index of stations in Rhode Island.*

Names of stations.	Page.	Names of stations.	Page.
Achilles.	434	Bunker Hill.	434
Ajax.	434	Burnt Swamp (Borden) (Mass.).	432
Alumpond (Borden) (Mass.).	432	Bushy Hill.	436
Anderson's barn, cupola.	424	Buttonwood House, cupola.	426
Anthony.	416	Butts.	416
Apponaug, spire.	428	Butts 2.	416
Arnold.	418	Calf Pasture Point.	424
Austin.	432	Castle Hill.	428
Babcock.	426	Castle Island Beacon, 1843.	428
Balch's house, north chimney.	416	Champlin.	412
Bald Hill (Borden) (Mass.).	432	Church's Point.	416
Barber's Heights.	422	Church's Point 2.	414
Barker.	416	Coal Mines, middle chimney.	422
Barn, cupola.	430	College Hill.	412
Barn, west gable.	424	Commons.	434
Barn, white cupola.	426	Conanicut North.	422
Batty.	420	Connimicut.	426
Batty's farm.	418	Copecut (Mass.).	412
Beaconpole.	412	Cormorant Hill.	436
Beaconpole (Borden).	432	Cornell.	416
Beavertail light-house, 1839-1843.	428	Cranberry Hill.	432
Beavertail light-house, 1869.	422	Cranberry Hill 2.	434
Bentley.	438	Cuttyhunk (Mass.).	412
Big Hill.	436	Davis' (O.) house, east gable, chimney.	438
Blackbeard (Mass.).	416	Diamond Hill, tree.	436
Block Island.	412	Dumplin.	422
Block Island, derrick.	436	Dumplin 2.	422
Block Island north light-house, 1838.	434	Dunn's house, white chimney.	438
Block Island north light-house, 1874.	436	Dutch Island, flagstaff, 1868.	430
Block Island southeast light-house, 1875.	436	Dutch Island light-house, 1868.	430
Blue Hill (Mass.).	412	Dyer's Island.	428
Border Hill, topographical pole.	438	East Rock.	412
Boston Neck.	430	Eel's Hill 2 (Ct.).	436
Bristol court-house.	428	Fair Grounds, tower.	414
Bristol, Methodist church.	424	Fall River (Mass.).	418
Broad Hill.	412	Fish-house, chimney.	430
Browning's house, chimney.	430	Fogland Point House, north gable.	414
Browning's (W. T.) house, center chimney.	438	Fort Adams, flagstaff, 1843.	428
Brown's (E.) house, chimney.	438	Fort Adams, flagstaff, 1869.	424
Brown's house, cupola.	420	Fort Hill.	434
Bullock's Neck.	418	Fort Independence.	418
Bullock's Neck (Borden).	418	Fort Independence 2.	420
Bullock's Neck 2.	418	Four Corners, belfry.	416

*Index of stations in Rhode Island.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Fox Island.	428	Lawton's house, flagstaff.	416
Fox Island, house, chimney.	430	Liberty pole.	438
Fox Point, rolling mill, chimney.	420	Little Compton.	414
Frost (Ct.).	436	Little Compton church spire.	414
Gibbs.	416	Little Compton 2.	414
Gibbs 2.	414	McSparran.	412
Goat Island light-house, 1843.	428	McSparran 2.	422
Gould Island.	428	Massachusetts North Base (Mass.).	412
Gould Island, barn cupola.	422	Massachusetts South Base (Mass.).	412
Governor's Island.	434	Meetinghouse Hill.	432
Great Meadow (Mass.).	412	Meetinghouse Hill 2.	434
Great Rock (Mass.).	432	Miantonomy.	422
Green Hill.	432	Montauk 2, N. Y.	436
Green's barn, cupola.	430	Mound.	414
Green's Point.	426	Mount Daniel (Borden) (Mass.).	432
Griswold's barn, south cupola.	416	Mount Hope.	412
Halfway Rock.	428	Mount Hope (Borden).	418
Hall.	426	Mount Hope 2.	414
Hall's (Ben.) house, west chimney.	424	Munroe (Borden).	432
Hamilton's Mills, cupola.	430	<b>Narragansett Bay.</b>	420
Harris' barn, east cupola.	438	Narragansett church.	430
Hazard.	422	Nayatt light-house, 1843.	426
Hazard's (A. P.) house, center chimney.	438	Nayatt light-house, 1863.	426
Hazard's Castle.	438	Neutaconkanut.	418
Hector.	434	Newport, Belmont's house, cupola.	424
High Hill.	416	Newport, Bronson's house, flagstaff.	424
High Rocks.	422	Newport, Catholic church, spire.	424
Hiscox.	434	Newport church.	422
Hog Island.	428	Newport, Ocean House.	424
Hog Island 2.	424	New Weeden.	434
Hog Island 3.	422	Nootas (Mass.).	412
Hope Island.	426	Nootas (Borden) (Mass.).	414
Hope Island, barn.	426	Northeast corner of Connecticut (Borden).	432
Howland's barn, cupola.	416	North Popasquash.	426
Hull.	422	Northwest corner of Rhode Island (Borden).	432
James.	436	North Windmill.	414
Joe Sanford (Borden) (Mass.).	418	Noyes' Neck.	434
Joe's Rock (Borden) (Mass.).	432	Noyes' Point.	432
Joshua Champlin.	432	Nye's (R.) house, white chimney.	438
Kenyon.	434	Paine.	436
Kenyon's (H. G.) house, center chimney.	438	Pappoose Squaw.	426
Kettle Point.	420	Pappoose Squaw 2.	424
King's Rock (Borden) (Mass.).	432	Paradise Rock.	414
Kingston church spire, 1838-1869.	434	Patience.	428
Kinnicut.	418	Pawkhungernock church.	434
Knapp's Point, house, chimney.	438	Pawtucket dark spire.	418
Lantern Hill (Ct.).	412	Pawtucket spire (Borden).	418



*Index of stations in Rhode Island.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Pawtuxet.	418	Quonsett 3.	422
Pawtuxet Beacon, 1843.	420	Red Brush.	432
Pawtuxet (Borden).	418	Reynolds.	428
Pawtuxet church spire, 1863.	420	<b>Rhode Island and Massachusetts Bound-</b>	
Pawtuxet spire, 1843.	420	<b>ary.</b>	432
Peirce's barn, cupola.	436	Rocky Point.	426
Peleg Tiff.	432	Rocky Point Hotel, chimney.	426
Pierce's barn.	420	Rose Island.	428
Pine Hill.	422	Rose Island flagstaff.	424
Pocasset.	412	Rumstick.	426
Point Judith.	432	Sable Point.	418
Point Judith light-house, 1838.	434	Sakonnet Point.	416
<b>Point Judith to Knapp's Point.</b>	432	<b>Sakonnet River and Mount Hope Bay.</b>	414
Pojack.	428	Sanders' (E.) house, chimney.	438
Pomham.	420	Sandhill.	436
Pomham Beacon, 1843.	420	Sandy Point.	424
Poorhouse, belfry.	428	Sandford's Mill, cupola.	430
Poorhouse, northeast gable.	430	Schoolhouse, chimney.	430
Portsmouth, belfry.	416	<b>Secondaries.</b>	412
Portsmouth Grove, flagstaff.	424	Seventh-Day meeting-house, north chimney.	438
Potter's (A.) house, chimney.	424	Shannock.	434
Potter's (Dr.) house, chimney.	424	Shaw's (Peter) barn, cupola.	414
Potter's (Widow) barn.	416	Sherman.	434
Potter's windmill, shaft.	430	Sherman's house, chimney.	428
<b>Primaries.</b>	412	Sherman's (J. P.) house, center chimney.	436
Prince.	428	Signal flag.	430
Prospect Hill.	418	Simmons.	414
Providence, Baptist church.	420	Simmons 2.	414
Providence, Congregational church.	420	Slate.	422
Providence, High street church.	420	Slate Hill flagstaff, 1869.	414
Providence, Quaker College.	420	Smith's barn, cupola.	430
<b>Providence River.</b>	418	South Portsmouth, Episcopal church, tower.	414
Providence, Unitarian church, 1843.	420	South Portsmouth, Union church, tower.	414
Providence, Unitarian church, 1863.	420	South Rock.	428
Providence Vitriol Works, chimney.	420	Spar Island.	416
Prudence.	422	Spencer.	412
Prudence Island light-house, 1861.	430	Stargut Island, house, northeast gable.	420
Prudence Island light-house, 1869.	424	Stevens.	418
Prudence South.	422	Sugarloaf Hill.	436
Prudence 2, 1869.	422	Tefft's barn, cupola.	430
Quaker.	412	Tefft's house, chimney.	424
Quicksand (Mass.).	414	Telegraph.	422
Quicksand (Borden) (Mass.).	414	Telegraph 2.	422
Quicksand 2 (Mass.).	414	Tiff.	432
Quonochontaug.	434	Tiverton, cupola.	416
Quonsett.	422	Topographical pole near post-road.	438
Quonsett 2.	424	Topographical pole 3.	438

*Index of stations in Rhode Island.—Continued.*

Names of stations.	Page.	Names of stations.	Page.
Topographical pole 4.	438	Weeden.	432
Topographical pole 6.	438	Wells' Hill.	436
Tower Hill church.	436	West.	424
Toweset.	416	Westerly.	438
Toweset Neck (Borden).	418	West Island, New York Club, flagstaff, 1869.	416
Vaughn's house, cupola.	430	Wharton's (Dr.) house, east chimney.	438
Verification, north base (Borden) (Mass.).	418	White house, north chimney.	426
Verification, south base (Borden) (Mass.).	418	White house, west chimney.	436
Village Hill.	434	Whitman.	412
Vue de l'Eau Hotel.	420	Wickford.	420
Wakefield church, gray spire.	436	Wickford Academy.	430
Wakefield church, white spire.	436	Wickford Baptist church.	430
Wakefield, flagstaff.	436	Wickford light-house, 1843.	428
Warren Beacon, 1863.	426	Wickford light-house, 1868.	430
Warren, Methodist spire.	426	Wickford, spire.	428
Warren, spire.	428	Wilbur.	434
Warwick Beacon, 1843.	426	Wilbur's windmill.	416
Warwick light-house, 1843.	426	Wilcox.	432
Warwick light-house, 1863.	424	Windmill.	416
Warwick Neck.	426	Windmill 2, 1869.	414
Watch Hill.	412	Wing.	414
Watch Hill light-house, 1838.	434	Yellow barn, cupola, Narragansett Bay.	426
Watch Hill light-house, 1873.	436	Yellow barn, cupola.	438
Watson's house, chimney.	424	Yellow house, west chimney.	426

## PRIMARY STATIONS.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Blue Hill, astronomical azimuth station, Massachusetts, 1845.	42 12 43.941	1355.7	71 06 52.638	1207.3
Copecut, astronomical azimuth station, Massachusetts, 1844 (C. & G. S. & B.).	41 43 17.245	532.1	71 03 36.644	847.1
Beaconpole, astronomical azimuth station, 1844.	41 59 42.468	1310.2	71 27 01.257	28.9
Great Meadow, Massachusetts (C. & G. S. & B.).	41 52 45.138	1392.7	71 13 02.292	52.9
Massachusetts North Base, Massachusetts. 1844.	42 03 06.592	203.4	71 12 24.871	572.0
Massachusetts South Base, Massachusetts. 1844.	41 54 49.921	1540.3	71 18 16.114	371.3

## SECONDARY STATIONS.

Spencer, astronomical azimuth station, 1844.	41 40 43.256	1334.4	71 29 40.685	941.0
Quaker (C. & G. S. & B.).	41 34 57.376	1770.1	71 15 18.337	424.7
Cuttyhunk, Massachusetts (C. & G. S. & B.).	41 25 14.887	459.3	70 56 02.646	61.4
McSparran.	41 29 46.953	1448.5	71 27 24.737	573.7
Pocasset (C. & G. S. & B.).	41 39 09.420	290.6	71 11 32.364	748.9
East Rock.	41 27 04.650	143.4	71 11 38.340	889.9
Nootas, Massachusetts.	41 32 13.020	401.6	71 07 25.832	598.8
Block Island.	41 10 32.077	989.5	71 35 30.644	714.3
Broad Hill.	41 24 39.953	1232.5	71 33 42.824	994.6
Champlin.	41 29 16.000	493.6	71 46 47.766	1108.2
Lantern Hill, Connecticut.	41 27 37.929	1170.1	71 56 40.826	947.5
Watch Hill.	41 18 49.932	1540.4	71 51 17.201	400.1
College Hill.	41 50 18.850	581.6	71 24 00.627	14.5
Mount Hope.	41 40 26.130	806.1	71 14 26.209	606.2
Whitman.	41 40 33.889	1045.5	71 27 19.357	447.6

## PRIMARY STATIONS.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
175 17 06.299	355 14 55.237	Blue Hill.....	54694.51	4.7379437
228 55 19.774	49 08 50.124	Blue Hill.....	36777.41	4.5655811
313 02 37.562	133 18 14.851	Copecut.....	44425.23	4.6476297
123 44 56.597	303 35 35.905	Beaconpole.....	23223.72	4.3659318
192 54 36.214	12 58 43.781	Blue Hill.....	37951.70	4.5792312
2 34 36.135	182 34 11.112	Great Meadow.....	19193.11	4.2831454
72 44 05.443	252 34 18.759	Beaconpole.....	21123.09	4.3247575
207 47 11.966	27 51 06.916	North Base.....	17326.376	4.2387077
127 46 54.940	306 41 03.861	Beaconpole.....	15091.32	4.1787273

## SECONDARY STATIONS.

185 57 36.34	5 59 22.68	Beaconpole.....	35339.35	4.5482586
262 22 17.91	82 39 38.36	Copecut.....	36475.19	4.5619976
226 24 37.79	46 32 24.14	Copecut.....	22393.41	4.3501202
118 12 27.73	298 02 54.85	Spencer.....	22634.29	4.3547668
123 56 41.52	303 43 55.71	Quaker.....	32270.72	4.5088086
162 33 26.03	342 28 24.78	Copecut.....	35009.26	4.5441829
171 10 21.59	351 08 51.35	Spencer.....	20491.06	4.3115644
240 18 12.34	60 26 14.04	Quaker.....	19370.85	4.2871487
150 41 04.12	330 30 44.69	Beaconpole.....	43666.53	4.6401487
235 09 32.46	55 14 48.84	Copecut.....	13397.89	4.1270365
160 44 27.59	340 42 01.77	Quaker.....	15450.37	4.1889388
278 46 25.33	98 56 44.56	Cuttyhunk.....	21986.15	4.3421491
309 04 33.44	129 12 05.94	Cuttyhunk.....	20436.54	4.3104073
156 03 33.63	336 00 49.97	Pocasset.....	14058.13	4.1479275
197 33 03.29	17 38 24.22	McSparran.....	37376.15	4.5725945
227 16 59.28	47 32 44.86	East Rock.....	45250.01	4.6556187
5 29 19.04	185 28 07.89	Block Island.....	26276.50	4.4195676
222 46 57.27	42 51 07.57	McSparran.....	12911.69	4.1109830
335 30 49.75	155 38 16.93	Block Island.....	38080.36	4.5807010
267 51 56.97	88 04 47.49	McSparran.....	26995.50	4.4312914
316 51 10.25	137 05 08.88	Block Island.....	43293.35	4.6364212
257 32 43.91	77 39 16.69	Champlin.....	14089.65	4.1489001
304 46 59.34	124 57 23.39	Block Island.....	26863.71	4.4291660
155 15 02.20	335 11 28.24	Lantern Hill.....	17940.44	4.2538331
253 23 08.32	73 30 27.63	Great Meadow.....	15841.36	4.1997926
7 06 04.06	187 03 48.37	McSparran.....	38298.07	4.5831769
6 47 22.05	186 46 47.42	Quaker.....	10213.98	4.0091950
300 27 25.96	120 29 21.52	Pocasset.....	4666.63	3.6690033
276 41 44.91	96 52 14.43	Pocasset.....	22063.36	4.3436717
0 21 29.76	180 21 26.18	McSparran.....	19959.02	4.3001393

## SAKONNET RIVER AND MOUNT HOPE BAY.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Simmons.	41 29 32.288	996.2	71 09 34.214	793.5
Quicksand, Massachusetts.	41 30 01.683	51.9	71 07 12.194	282.8
Nootas (Borden), Massachusetts.	41 32 13.094	404.0	71 07 25.874	599.8
Wing.	41 35 23.225	716.7	71 11 10.352	239.8
Paradise Rock.	41 30 05.511	169.9	71 15 45.504	1055.3
Windmill 2. 1869.	41 32 33.559	1035.2	71 11 50.508	1170.6
Simmons 2. 1870.	41 29 32.078	989.7	71 09 34.665	804.1
Little Compton.	41 31 12.385	382.2	71 11 00.706	16.3
Little Compton 2. 1870.	41 31 12.440	383.7	71 11 01.694	39.3
Little Compton, church spire.	41 30 33.635	1037.5	71 10 18.351	425.5
Church's Point 2. 1869.	41 30 09.917	305.9	71 12 21.012	487.2
South Portsmouth, Episcopal church tower.	41 32 50.304	1551.9	71 15 42.342	981.4
South Portsmouth, Union church tower.	41 33 30.179	931.1	71 15 21.902	507.8
Slate Hill, flagstaff. 1869.	41 32 22.154	683.6	71 15 56.410	1307.4
Fair grounds, tower.	41 31 16.608	512.3	71 16 27.837	645.4
Gibbs 2. 1869.	41 29 39.540	1219.7	71 16 28.381	658.2
Fogland Point House, north gable.	41 33 42.896	1323.4	71 13 11.652	269.9
North Windmill.	41 35 16.013	494.0	71 15 16.018	371.0
Mount Hope 2. 1874.	41 40 26.515	818.0	71 14 26.094	603.6
Mound.	41 38 14.042	433.2	71 13 11.906	275.4
Quicksand 2, Massachusetts. 1870.	41 29 56.40	1740.0	71 07 09.16	212.4
Quicksand (Borden), Massachusetts.	41 30 01.73	53.4	71 07 12.18	282.5
Shaw's (Peter) barn, cupola.	41 29 14.50	447.3	71 08 45.72	1060.6

## SAKONNET RIVER AND MOUNT HOPE BAY.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
210 58 02.0	30 59 27.1	Nootas .....	5783.7	3.762207
32 19 10.1	212 17 47.9	East Rock.	5388.9	3.731504
175 32 19.6	355 32 10.6	Nootas .....	4064.2	3.608975
74 37 19.5	254 35 45.4	Simmons.	3416.7	3.533609
309 04 44.8	129 12 17.3	Cuttyhunk .....	20438.7	4.310454
114 53 04.2	294 47 50.8	Quaker.	12064.5	4.081508
154 08 19.3	334 06 09.2	Mount Hope .....	10386.6	4.016473
82 07 08.5	262 04 23.9	Quaker.	5799.2	3.763371
213 01 28.1	33 04 30.6	Wing .....	11693.8	4.067957
314 11 29.3	134 14 12.9	East Rock.	8001.3	3.903161
132 40 28.7	312 38 10.8	Quaker .....	6548.1	3.816114
50 03 00.5	230 00 24.7	Paradise Rock.	7109.8	3.851855
96 52 18.7	276 48 13.0	Paradise Rock .....	8663.3	3.937683
32 15 42.2	212 14 20.3	East Rock.	5377.9	3.730613
139 19 18.0	319 16 27.1	Quaker .....	9155.9	3.961700
249 23 57.3	69 26 19.8	Nootas.	5321.2	3.726012
72 36 29.8	252 33 21.7	Paradise Rock .....	6897.9	3.838715
326 53 33.1	146 54 30.8	Simmons 2.	3696.0	3.567735
139 30 46.0	319 27 27.0	Quaker .....	10702.7	4.029492
139 59 16.9	319 58 48.2	Little Compton 2.	1563.1	3.193998
189 03 55.5	9 04 15.7	Windmill 2. ....	4487.5	3.652007
88 22 38.6	268 20 23.1	Paradise Rock.	4744.8	3.676216
188 04 23.9	8 04 39.8	Quaker .....	3959.6	3.597650
0 49 36.4	180 49 34.3	Paradise Rock.	5084.5	3.706246
181 45 30.8	1 45 33.2	Quaker .....	2691.3	3.429967
76 59 33.1	256 54 45.0	Hull.	10333.1	4.014232
356 33 58.4	176 34 05.6	Paradise Rock .....	4223.1	3.625628
266 26 40.9	86 29 24.0	Windmill 2.	5710.7	3.756691
67 54 33.6	247 53 07.7	Miantonomy .....	3243.5	3.511010
335 53 02.3	155 53 30.4	Paradise Rock.	2403.1	3.380763
231 08 26.9	51 08 55.3	Paradise Rock .....	1277.1	3.106234
120 40 10.9	300 38 44.5	Miantonomy.	3479.5	3.541511
318 40 21.9	138 41 15.7	Windmill 2. ....	2848.2	3.454567
128 04 07.4	308 02 43.4	Quaker.	3727.6	3.571424
5 20 12.2	185 20 10.7	Quaker .....	577.5	2.761554
113 13 14.1	293 10 57.5	Prudence 2.	5185.4	3.714779
62 15 31.6	242 11 25.8	Pine Hill. ....	9668.8	3.985375
6 47 47.5	186 47 12.8	Quaker.	10226.1	4.009711
157 13 25.6	337 12 36.3	Mount Hope 2 .....	4432.8	3.646681
25 46 07.3	205 44 43.3	Quaker.	6736.7	3.828449
113 31 48	293 29 14	Little Compton 2 .....	5880.7	3.76943
77 28 34	257 26 58	Simmons 2.	3457.5	3.53876
175 31 13	355 31 04	Nootas (Borden) .....	4065.1	3.60907
299 36 00	119 43 23	Cuttyhunk.	17881.7	4.25241
115 31 56	295 31 24	Simmons .....	1258.2	3.09976
239 59 56	60 01 00	Quicksand 2.	2586.1	3.41265

## SAKONNET RIVER AND MOUNT HOPE BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Wilbur's windmill.	41 29 24.36	751.7	71 11 02.56	59.4
West Island, New York Club, flagstaff. 1869.	41 27 00.81	25.0	71 11 59.03	1370.1
Griswold's barn, south cupola.	41 32 58.69	1810.7	71 14 20.83	482.8
Howland's barn, cupola.	41 32 04.17	128.6	71 11 46.08	1068.3
Lawton's house, flagstaff.	41 37 33.40	1030.4	71 12 48.97	1133.5
Portsmouth, belfry.	41 36 13.34	411.5	71 14 53.67	1242.7
Potter's (Widow) barn.	41 33 18.00	555.3	71 12 17.07	395.5
Four Corners, belfry.	41 34 31.52	972.3	71 11 22.41	519.1
Balch's house, north chimney.	41 29 00.51	15.7	71 16 20.91	485.1
Butts.	41 36 55.84	1722.7	71 15 06.56	151.9
Butts 2. 1861.	41 36 55.74	1719.6	71 15 07.48	173.2
Anthony.	41 38 46.35	1429.9	71 13 18.64	431.4
Blackbeard (Massachusetts).	41 40 28.88	891.0	71 10 58.83	1360.8
Toweset.	41 41 59.23	1827.3	71 14 33.74	780.2
Spar Island.	41 41 17.40	536.8	71 13 14.68	339.5
Tiverton cupola.	41 37 30.25	933.2	71 12 50.91	1178.5
Barker.	41 38 23.01	709.9	71 12 06.65	153.9
Cornell.	41 37 18.96	584.9	71 09 16.52	382.4
Windmill.	41 32 33.62	1037.2	71 11 50.48	1170.1
Church's Point.	41 30 00.12	3.7	71 12 23.96	555.7
Gibbs.	41 29 36.69	1131.9	71 16 29.18	676.9
Sakonnet Point.	41 27 16.36	504.7	71 11 46.09	1069.8
High Hill.	41 32 51.03	1574.3	71 12 59.46	1378.1

## SAKONNET RIVER AND MOUNT HOPE BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
263 19 56	83 20 54	Simmons 2 .....	2052.8	3.31235
180 20 44	0 20 45	Little Compton 2 .....	3334.4	3.52301
97 11 32	277 06 06	Telegraph 2 .....	11522.0	4.06153
137 20 18	317 17 48	Paradise Rock .....	7751.1	3.88936
224 41 08	44 43 14	Wing .....	6273.6	3.79752
282 31 47	102 33 37	Windmill 2 .....	3569.2	3.55257
137 23 28	317 21 07	Quaker .....	7262.8	3.86110
173 32 27	353 32 24	Windmill .....	912.6	2.96026
330 22 04	150 23 09	Wing .....	4619.7	3.66461
351 40 00	171 40 39	Windmill 2 .....	9348.8	3.97076
327 56 31	147 58 33	Windmill 2 .....	7998.7	3.90302
286 37 13	106 39 41	Wing .....	5398.1	3.73224
126 08 50	306 06 50	Quaker .....	5199.9	3.71600
335 48 52	155 49 10	Windmill 2 .....	1502.8	3.17690
189 56 02	9 56 10	Wing .....	1619.7	3.20943
10 08 44	190 08 25	Windmill 2 .....	3696.7	3.56782
202 16 16	22 16 39	Paradise Rock .....	2167.1	3.33589
67 08 25	247 05 52	Telegraph 2 .....	5810.1	3.76418
297 33 40	117 36 17	Wing .....	6171.2	3.79037
4 16 17	184 16 09	Quaker .....	3665.1	3.56408
104 45 03	284 41 25	Pine Hill .....	7858.5	3.89534
188 22 00	8 22 27	Mount Hope .....	6560.5	3.81694
36 14 21	216 13 09	Butts .....	4226.5	3.62598
153 04 38	333 03 53	Mount Hope .....	3452.6	3.53815
17 33 47	197 33 25	Pocasset .....	2571.2	3.41014
89 00 23	268 58 05	Mount Hope .....	4797.7	3.68103
299 15 58	119 18 20	Blackbeard .....	5698.5	3.75576
356 31 47	176 31 51	Mount Hope .....	2877.5	3.45902
46 17 39	226 16 51	Mount Hope .....	2288.9	3.35963
125 13 50	305 12 57	Toweset .....	2237.8	3.34983
35 54 53	215 53 15	Quaker .....	5822.2	3.76509
157 53 23	337 52 20	Mount Hope .....	5857.2	3.76769
34 59 50	214 57 43	Quaker .....	7742.3	3.88887
139 38 41	319 37 08	Mount Hope .....	4985.6	3.69772
62 30 03	242 26 03	Quaker .....	9448.9	3.97538
137 19 03	317 17 33	Pocasset .....	4636.9	3.66623
132 39 29	312 37 08	Quaker .....	6547.7	3.81609
166 07 11	346 05 26	Mount Hope .....	15016.9	4.17658
156 13 52	336 11 56	Quaker .....	10021.4	4.00093
171 40 11	351 38 50	Mount Hope .....	19520.0	4.29048
59 54 34	239 52 42	Hazard .....	4516.4	3.65479
122 03 32	302 02 07	Miantonomy .....	3509.6	3.54526
160 55 58	340 53 37	Quaker .....	15050.1	4.17744
171 21 24	351 19 38	Mount Hope .....	24646.2	4.39175
140 28 21	320 26 49	Quaker .....	5054.8	3.70370
171 52 00	351 51 02	Mount Hope .....	14183.4	4.15178



## SAKONNET RIVER AND MOUNT HOPE BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Mount Hope (Borden).	41 40 27.55	849.9	71 14 26.15	604.9
Joe Sanford (Borden), Massachusetts.	41 35 37.56	1158.7	71 07 55.53	1286.1
Fall River (Massachusetts).	41 42 39.25	1210.9	71 08 45.54	1052.8
Toweset Neck (Borden).	41 42 45.02	1388.9	71 13 36.28	838.7

## PROVIDENCE RIVER.

Pawtucket dark spire, 1885.	41 52 53.95	1664.5	71 23 05.06	116.7
Pawtucket spire (Borden), 1836.	41 52 36.04	1111.9	71 22 53.84	1241.5
Arnold.	41 45 14.48	446.7	71 23 41.75	964.6
Kinnicut.	41 47 47.84	1475.9	71 21 57.48	1327.1
Fort Independence.	41 47 34.44	1062.5	71 23 33.38	770.7
Neutaconkanut.	41 48 41.08	1267.4	71 28 03.06	70.6
Batty's Farm.	41 45 34.90	1076.7	71 24 35.80	827.0
Prospect Hill.	41 49 44.64	1377.2	71 24 20.85	481.1
Bullock's Neck (Borden).	41 44 42.27	1304.1	71 21 35.11	811.2
Bullock's Neck.	41 44 42.90	1323.5	71 21 27.69	639.8
Bullock's Neck 2, 1863.	41 44 43.00	1326.6	71 21 35.16	812.3
Verification South Base (Borden), 1836, Massachusetts.	41 50 13.04	402.3	71 21 28.68	661.8
Verification North Base (Borden), 1836, Massachusetts.	41 54 25.94	800.3	71 21 20.68	476.6
Stevens.	41 44 44.13	1361.5	71 22 56.05	1295.1
Sable Point.	41 46 02.38	73.4	71 22 06.14	141.8
Pawtuxet (Borden).	41 45 14.19	436.8	71 23 41.72	963.9
Pawtuxet.	41 45 56.80	1752.4	71 23 13.95	322.2

## SAKONNET RIVER AND MOUNT HOPE BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
300 55 58	120 57 54	Pocasset.....	4688.3	3.67102
6 46 05	186 45 30	Quaker.	10258.0	4.01106
353 46 48	173 47 08	Nootas (Borden) .....	6345.6	3.80247
83 08 51	263 03 57	Quaker.	10331.1	4.01415
62 29 50	242 26 03	Mount Hope.....	8884.4	3.94863
30 48 42	210 46 51	Pocasset.	7536.0	3.87714
271 29 33	91 32 46	Fall River.....	6723.7	3.82761
15 13 08	195 12 35	Mount Hope (Borden).	4394.4	3.64290

## PROVIDENCE RIVER.

156 40 20	336 37 42	Beaconpole .....	13728.4	4.13762
271 03 51	91 10 33	Great Meadow.	13901.1	4.14305
173 37 47	353 36 51	Joe's Rock .....	17290.3	4.23780
284 06 07	104 09 53	Great Rock.	8046.8	3.90562
304 39 29	124 45 39	Mount Hope.....	15622.8	4.19376
30 10 50	210 08 25	Whitman.	10012.0	4.00052
322 32 00	142 37 00	Mount Hope.....	17160.1	4.23452
29 05 06	209 01 32	Whitman.	15315.8	4.18514
316 12 33	136 18 37	Mount Hope.....	18290.3	4.26222
2 33 58	182 33 52	Arnold.	4322.4	3.63572
288 15 00	108 18 00	Fort Independence.....	6556.6	3.81668
316 32 36	136 35 30	Arnold.	8777.3	3.94336
140 13 05	320 10 47	Neutaconkanut .....	7476.9	3.87372
201 20 43	21 21 25	Fort Independence.	3960.0	3.59769
344 43 53	164 44 25	Fort Independence.....	4163.0	3.61941
69 07 15	249 04 47	Neutaconkanut.	5490.1	3.73958
306 19 38	126 26 19	Pocasset.....	17311.8	4.23834
334 10 54	154 15 04	Quaker.	20039.7	4.30189
107 28 18	287 26 49	Arnold.....	3247.1	3.51149
151 15 51	331 14 27	Fort Independence.	6036.3	3.78077
357 34 42	177 34 46	Connimicut .....	3129.0	3.49541
322 48 48	142 49 37	Nayatt light-house, 1863.	2802.3	3.44751
169 49 19	349 47 26	Joe's Rock .....	21942.1	4.34128
247 14 49	67 17 38	Great Rock.	6333.1	3.80161
313 25 31	133 28 14	Great Rock.....	7787.7	3.89141
1 21 22	181 21 17	Verification South Base.	7804.4	3.89234
271 03 49	91 04 43	Bullock's Neck 2 .....	1869.4	3.27170
327 39 00	147 39 58	Connimicut.	3741.5	3.57305
343 42 21	163 42 42	Bullock's Neck 2 .....	2551.6	3.40682
25 31 56	205 31 23	Stevens.	2675.5	3.42740
177 20 36	357 20 23	College Hill .....	9409.4	3.97356
288 35 09	108 36 33	Bullock's Neck (Borden.).	3086.2	3.48942
263 43 23	83 44 08	Sable Point .....	1575.6	3.19745
349 33 01	169 33 13	Stevens.	2279.9	3.35792

## PROVIDENCE RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Fort Independence 2, 1863.	41 47 34.41	1061.6	71 23 33.49	773.3
Kettle Point.	41 47 46.34	1429.7	71 22 41.04	947.6
Brown's house cupola.	41 45 04.44	137.0	71 23 24.20	559.1
Pawtuxet church spire, 1863.	41 45 59.12	1823.9	71 23 30.53	705.2
Vue de l'Eau Hotel.	41 47 15.82	488.1	71 22 05.09	117.5
Stargut Island house, northeast gable.	41 47 10.00	308.5	71 22 55.92	1291.3
Pierce's barn.	41 48 22.47	693.2	71 22 59.79	1380.2
Fox Point Rolling Mill, chimney.	41 48 59.70	1841.8	71 23 55.82	1288.3
Pomham.	41 46 42.15	1300.4	71 21 28.04	647.6
Pomham Beacon. 1843.	41 46 35.13	1083.8	71 22 27.08	625.5
Pawtuxet spire. 1843.	41 45 59.34	1830.7	71 23 30.50	704.6
Providence, Baptist church.	41 49 38.92	1200.7	71 24 32.12	741.2
Providence, Unitarian church. 1843.	41 49 27.89	860.4	71 24 19.99	461.3
Providence, Congregational church.	41 49 12.90	398.0	71 24 50.78	1172.0
Providence, Quaker College.	41 50 00.56	17.3	71 23 56.34	1300.0
Providence, High street church.	41 49 05.73	176.8	71 25 16.25	375.1
Providence, Unitarian church. 1863.	41 49 27.88	860.1	71 24 20.08	463.4
Providence Vitriol Works, chimney.	41 49 49.56	1529.0	71 25 21.92	505.9
Pawtuxet Beacon. 1843.	41 45 35.56	1097.1	71 22 50.95	1177.0

## NARRAGANSETT BAY.

Wickford.	41 34 30.541	942.1	71 28 02.688	62.3
Batty.	41 32 13.240	408.5	71 22 36.230	839.9

## PROVIDENCE RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
324 36 03	144 37 01	Sable Point .....	3483.0	3.54195
351 28 30	171 28 43	Pawtuxet.	3045.1	3.48360
345 53 40	165 54 03	Sable Point .....	3307.0	3.51944
372 40 41	192 40 19	Pawtuxet.	3463.9	3.53957
225 14 44	45 15 36	Sable Point .....	2539.1	3.40468
284 42 17	104 43 30	Bullock's Neck 2.	2605.0	3.41580
178 40 04	358 40 02	Fort Independence 2 .....	2940.0	3.46850
267 01 52	87 02 48	Sable Point.	1951.8	3.29044
33 07 23	213 06 37	Pawtuxet. ....	2910.8	3.46401
105 42 04	285 41 05	Fort Independence 2.	2120.2	3.32638
130 58 06	310 57 41	Fort Independence 2 .....	1149.0	3.06031
197 02 04	17 02 14	Kettle Point.	1172.7	3.06919
338 46 28	158 46 40	Kettle Point .....	1195.9	3.07769
27 41 27	207 41 05	Fort Independence 2.	1674.5	3.22388
322 39 36	142 40 26	Kettle Point .....	2846.6	3.45432
348 54 53	168 55 08	Fort Independence 2.	2681.4	3.42836
319 54 55	139 59 36	Mount Hope .....	15153.7	4.18052
48 48 16	228 46 47	Arnold.	4105.4	3.61336
34 44 06	214 43 16	Arnold .....	3027.6	3.48110
140 05 19	320 04 35	Fort Independence.	2385.6	3.37760
309 12 13	129 18 15	Mount Hope .....	16247.3	4.21078
27 48 11	207 45 39	Whitman.	11349.3	4.05497
313 48 55	133 50 38	Kinnicut .....	4947.9	3.69442
0 38 48	180 38 46	Batty's Farm.	7529.4	3.87676
320 34 00	140 40 35	Mount Hope .....	21624.2	4.33494
14 08 08	194 06 09	Whitman.	16987.9	4.23014
318 20 19	138 27 15	Mount Hope .....	21734.5	4.33715
12 06 47	192 05 08	Whitman.	16376.5	4.21422
323 19 35	143 25 55	Mount Hope .....	22081.6	4.34403
15 02 07	194 59 52	Whitman.	18101.3	4.25771
304 20 32	124 22 15	Kettle Point .....	4340.2	3.63751
319 53 34	139 54 43	Fort Independence 2.	3683.0	3.56620
323 52 10	143 53 16	Kettle Point .....	3878.2	3.58863
342 55 07	162 55 38	Fort Independence.	3662.1	3.56373
315 39 24	135 41 11	Kettle Point .....	5314.1	3.72543
329 00 56	149 02 08	Fort Independence.	4862.8	3.68689
61 01 12	241 00 38	Arnold .....	1341.6	3.12763
165 02 50	345 02 22	Fort Independence.	3796.5	3.57938

## NARRAGANSETT BAY.

354 15 15.0	174 15 40.2	McSparran .....	8793.1	3.944141
239 47 37.2	59 56 39.4	Mount Hope.	21854.1	4.339532
56 01 21.0	235 58 09.7	McSparran .....	8069.9	3.906866
119 16 28.8	299 12 52.3	Wickford.	8670.5	3.938043

## NARRAGANSETT BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Prudence.	41 36 24.417	753.3	71 18 42.589	986.2
Slate.	41 32 21.011	648.2	71 15 59.637	1382.3
Miantonomy.	41 30 37.049	1142.9	71 18 37.433	868.1
Hazard.	41 28 23.251	717.3	71 19 17.586	408.1
Telegraph.	41 27 47.828	1475.5	71 20 11.632	269.9
Telegraph 2. 1869.	41 27 47.279	1458.6	71 20 11.608	269.4
Pine Hill.	41 38 00.469	14.5	71 20 35.806	828.7
Hull.	41 32 14.564	449.3	71 22 36.229	839.9
Dumplin 2. 1869.	41 28 45.694	1409.6	71 22 07.834	181.8
Dumplin.	41 28 45.682	1409.3	71 22 07.859	182.3
McSparran 2. 1869.	41 29 47.786	1474.2	71 27 24.350	564.8
Barber's Heights.	41 31 44.871	1384.3	71 25 28.100	651.3
Beavertail light-house. 1869.	41 26 57.895	1786.1	71 23 59.574	1382.7
Prudence 2. 1869.	41 36 22.230	685.8	71 18 41.808	968.1
High Rocks.	41 37 47.560	1467.2	71 26 08.780	203.2
Quonsett.	41 35 26.582	820.1	71 24 33.702	780.6
Quonsett 3. 1868.	41 35 17.032	525.4	71 24 23.203	537.5
Prudence South.	41 34 44.455	1371.4	71 19 32.957	763.4
Conanicut North.	41 34 24.861	767.1	71 22 19.870	460.3
Newport church.	41 29 14.456	446.0	71 18 49.706	1153.1
Hog Island 3. 1874.	41 38 40.481	1248.8	71 16 50.822	1176.0
Coal Mines, middle chimney.	41 37 09.940	306.6	71 16 26.833	621.2
Gould Island, barn cupola.	41 32 02.029	62.6	71 20 41.058	951.9

## NARRAGANSETT BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
299 33 45.1	119 36 00.7	Quaker .....	5439.6	3.735563
34 57 28.3	214 54 53.2	Batty .....	9452.5	3.975545
73 24 24.5	253 16 50.3	McSparran .....	16581.6	4.219627
88 32 34.5	268 28 11.5	Batty .....	9196.3	3.963615
118 12 46.4	298 10 08.1	Batty .....	6281.8	3.798084
82 50 46.1	262 44 56.6	McSparran .....	12326.9	4.090855
147 01 21.4	326 59 09.7	Batty .....	8459.8	3.927360
192 42 43.7	12 43 10.3	Miantonomy .....	4231.5	3.626497
138 43 23.9	318 38 11.6	Wickford .....	16542.5	4.218602
202 42 20.5	22 43 22.9	Miantonomy .....	5659.5	3.752775
202 38 03.4	22 39 05.8	Miantonomy .....	5674.9	3.753957
178 04 18.5	358 04 18.5	Telegraph .....	17.0	1.229518
31 55 58.6	211 51 27.3	McSparran .....	17933.0	4.253654
307 30 33.8	127 34 04.6	Quaker .....	9270.7	3.967114
337 51 03.2	157 52 39.0	Telegraph 2 .....	8902.0	3.949488
298 29 46.6	118 32 24.9	Miantonomy .....	6301.2	3.799420
303 44 25.8	123 45 42.8	Telegraph 2 .....	3243.6	3.511027
234 50 19.3	54 52 38.7	Miantonomy .....	5968.3	3.775849
234 50 20.2	54 52 39.6	Miantonomy .....	5969.0	3.775899
104 26 59.1	284 23 29.1	McSparran .....	7590.2	3.880253
235 50 41.0	55 53 52.0	Hull .....	8070.9	3.906923
284 35 32.5	104 39 02.2	Dumplin 2. ....	7588.1	3.880150
36 44 41.2	216 43 24.1	McSparran 2 .....	4507.2	3.653906
257 02 09.1	77 04 03.1	Hull .....	4088.3	3.611543
137 49 26.9	317 47 11.3	McSparran .....	7074.4	3.849691
85 56 27.0	265 53 25.7	Meeting-house Hill 2. ....	6376.0	3.804547
359 27 15.2	179 27 18.1	Miantonomy .....	10649.6	4.027335
299 02 03.2	119 04 18.3	Quaker .....	5390.8	3.731653
334 27 45.0	154 30 06.1	Batty .....	11429.0	4.058008
6 46 35.5	186 45 45.1	McSparran .....	14931.3	4.174096
257 35 29.7	77 39 22.8	Prudence .....	8324.8	3.920374
335 27 35.8	155 28 53.7	Batty .....	6556.5	3.816672
12 56 44.6	192 56 01.5	Barber's Heights .....	6715.9	3.827105
336 13 28.8	156 14 39.8	Hull .....	6150.9	3.788937
266 06 36.5	86 09 25.5	Quaker .....	5911.8	3.771717
100 35 43.4	280 32 23.8	Quonsett .....	7086.6	3.850438
119 24 25.1	299 23 03.2	Quonsett 3 .....	3279.2	3.515766
41 29 16.6	221 27 11.7	Barber's Heights .....	6587.3	3.818707
82 00 34.1	261 51 40.3	Tiff .....	18888.0	4.276186
34 00 07.0	213 49 06.0	Block Island .....	41721.0	4.620355
342 42 37.5	162 43 38.9	Quaker .....	7208.4	3.857842
225 39 19.2	45 40 55.4	Mount Hope 2. ....	4681.3	3.670366
338 47 41.3	158 48 26.8	Quaker .....	4386.6	3.642125
43 14 04.9	223 09 59.8	Hull .....	12500.8	4.096938
98 15 10.1	278 13 53.7	Hull .....	2697.7	3.430991
312 26 08.3	132 27 30.3	Miantonomy .....	3884.5	3.589335

## NARRAGANSETT BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Hall's (Ben) house, west chimney.	41 35 08.267	255.0	71 16 414.328	957.3
Prudence Island light-house. 1869.	41 36 28.93	892.6	71 18 30.35	702.7
Taft's house, chimney.	41 28 01.34	41.3	71 27 37.94	880.4
Watson's house, chimney.	41 28 22.37	690.2	71 26 05.70	132.3
Barn, west gable.	41 28 35.10	1082.8	71 23 28.36	657.9
Potter's (Dr.) house, chimney.	41 27 00.95	29.3	71 26 30.46	707.0
Potter's (And.) house, chimney.	41 30 29.90	922.5	71 21 38.60	895.1
Newport, Ocean house.	41 28 53.24	1642.5	71 18 30.59	709.7
Newport, Catholic church spire.	41 28 49.06	1513.5	71 18 49.38	1145.6
Newport, Belmont's house, cupola.	41 27 52.17	1709.5	71 18 22.46	521.1
Newport, Bronson's house, flagstaff.	41 27 51.76	1596.8	71 21 28.23	655.0
Rose Island, flagstaff.	41 29 47.52	1466.0	71 20 34.30	795.4
Fort Adams, flagstaff. 1869.	41 28 45.88	1415.4	71 20 20.25	469.7
Anderson's barn, cupola.	41 33 41.31	1274.4	71 17 23.46	543.5
Portsmouth Grove, flagstaff.	41 35 13.03	401.9	71 17 13.73	318.0
West.	41 38 44.42	1370.4	71 15 42.00	972.0
Pappoose Squaw 2. 1861.	41 39 15.20	468.9	71 18 02.45	56.7
Hog Island 2. 1861.	41 38 40.48	1248.8	71 16 50.79	1175.4
Bristol, Methodist church.	41 40 15.39	474.8	71 16 31.88	737.5
Quonsett 2. 1863.	41 35 16.90	521.4	71 24 23.02	533.2
Calf Pasture Point.	41 37 40.62	1253.1	71 24 18.99	439.6
Warwick light-house. 1863.	41 40 01.43	44.1	71 22 43.28	1001.3
Sandy Point.	41 39 43.29	1335.5	71 24 37.14	859.2

## NARRAGANSETT BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
279 54 26.2	99 55 21.3	Quaker .....	1951.5	3.290379
129 17 10.8	309 15 50.8	Prudence 2. ....	3604.5	3.556849
0 52 02	180 51 57	Miantonomy .....	10856.7	4.03570
302 24 02	122 26 09	Quaker. ....	5268.0	3.72164
28 09 39	208 09 02	Meeting-house Hill 2 .....	2735.3	3.43700
185 29 03	5 29 12	McSparran 2. ....	3298.8	3.51836
48 17 04	228 15 26	Meetinghouse Hill 2 .....	4597.7	3.66254
262 33 03	82 35 41	Dumplin 2. ....	5566.0	3.74554
64 02 17	243 58 55	Meeting-house Hill 2 .....	7879.8	3.89651
260 04 23	80 05 16	Dumplin 2. ....	1896.7	3.27800
242 02 42	62 05 36	Dumplin 2 .....	6898.4	3.83875
166 21 04	346 20 28	McSparran 2. ....	5296.5	3.72399
11 54 48	191 54 29	Dumplin 2 .....	3285.5	3.51660
338 04 42	158 05 40	Telegraph 2. ....	5407.6	3.73300
49 02 56	229 01 49	Telegraph 2 .....	3404.1	3.49193
177 09 47	357 09 42	Miantonomy. ....	3206.6	3.50604
140 20 05	320 17 35	Hull .....	8238.1	3.91583
184 45 22	45 30	Miantonomy. ....	3342.7	3.52417
221 30 10	41 31 54	Paradise Rock .....	5493.8	3.73987
107 32 35	287 30 06	Dumplin 2. ....	5483.9	3.73909
217 50 02	37 51 55	Miantonomy .....	6457.8	3.81008
151 05 47	331 05 21	Dumplin 2. ....	1900.7	3.27890
240 34 35	60 35 52	Miantonomy .....	3111.6	3.49298
48 41 34	228 40 32	Dumplin 2. ....	2889.0	3.46074
89 52 52	269 51 41	Dumplin 2 .....	2496.2	3.39727
353 40 19	173 40 25	Telegraph 2. ....	1818.8	3.25978
159 55 33	339 54 41	Prudence .....	5285.7	3.72310
69 45 51	249 42 24	Hull. ....	7727.2	3.88802
53 38 50	233 35 16	Hull .....	9282.3	3.96765
136 18 37	316 17 39	Prudence 2. ....	2952.6	3.47021
78 44 54	258 41 39	Pine Hill .....	6933.8	3.84097
209 11 34	29 12 24	Mount Hope. ....	3594.7	3.55566
286 16 34	106 18 07	West .....	3385.9	3.52967
246 21 21	66 23 45	Mount Hope. ....	5460.3	3.73722
122 51 55	302 51 07	Pappoose Squaw 2 .....	1974.1	3.29536
225 43 54	45 45 30	Mount Hope. ....	4670.4	3.66935
263 29 11	83 30 35	Mount Hope .....	2925.7	3.46623
350 09 00	170 09 49	Quaker. ....	9957.7	3.99816
226 10 12	46 12 43	Pine Hill .....	7289.9	3.86272
299 21 34	119 22 56	Conanicut H. ....	3273.2	3.51497
263 13 13	83 15 41	Pine Hill .....	5202.2	3.71619
335 26 26	155 27 45	Conanicut N. ....	6639.6	3.82214
321 39 47	141 41 12	Pine Hill .....	4757.0	3.67733
27 01 20	207 00 16	Calf Pasture Point. ....	4876.2	3.68808
257 59 47	78 01 03	Warwick light-house, 1863 .....	2692.8	3.43020
353 40 00	173 40 12	Calf Pasture. ....	3807.9	3.58068



## NARRAGANSETT BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Green's Point.	41 41 03.60	111.1	71 24 43.18	998.6
Hope Island, barn.	41 36 09.97	307.6	71 22 00.42	9.7
Buttonwood house, cupola.	41 41 19.12	589.9	71 25 58.28	1347.8
Yellow barn, cupola.	41 41 01.77	54.6	71 27 13.58	314.1
White house, north chimney.	41 40 46.09	1421.9	71 27 04.36	100.8
North Popasquash.	41 40 54.61	1684.8	71 18 12.28	284.0
Nayatt light-house. 1863.	41 43 30.64	945.3	71 20 21.88	505.7
Rocky Point.	41 41 29.72	916.9	71 21 50.06	1157.6
Pappoose Squaw.	41 39 15.20	468.9	71 18 02.52	58.3
Rumstick.	41 42 24.05	742.0	71 18 07.76	179.4
Connimicut.	41 43 01.67	51.5	71 21 29.44	680.5
Babcock.	41 42 44.36	1368.5	71 18 24.80	573.3
Hall.	41 43 12.06	372.1	71 17 05.59	129.2
Rocky Point Hotel, chimney.	41 41 21.91	675.9	71 21 56.52	1307.0
Barn, white cupola.	41 42 22.66	699.1	71 16 55.43	1281.5
Warren Beacon. 1863.	41 42 48.74	1503.7	71 17 37.24	860.9
Warren, Methodist spire.	41 43 48.78	1504.9	71 17 02.72	62.9
Yellow house, west chimney.	41 43 41.87	1291.7	71 19 23.20	536.2
Warwick light-house. 1843.	41 40 01.44	44.4	71 22 43.33	1002.4
Warwick Neck.	41 41 21.10	650.9	71 22 49.72	1149.8
Warwick Beacon. 1843.	41 39 25.02	771.9	71 23 36.17	836.9
Nayatt light-house. 1843.	41 43 30.09	928.3	71 20 22.31	515.6
Hope Island.	41 36 10.30	317.8	71 21 59.62	1380.6

## NARRAGANSETT BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
304 39 24	124 40 44	Warwick light-house, 1863.....	3372.0	3. 52789
356 46 12	176 46 16	Sandy Point.....	2481.5	3. 39472
7 54 34	187 54 21	Conanicut N.....	3273.9	3. 51506
131 05 36	311 04 04	Calf Pasture Point.....	4256.0	3. 62900
297 58 12	118 00 22	Warwick light-house, 1863.....	5107.6	3. 70822
327 35 03	147 35 57	Sandy Point.....	3501.9	3. 54430
269 03 32	89 05 12	Green's Point.....	3479.2	3. 54148
303 46 08	123 47 52	Sandy Point.....	4354.3	3. 63892
260 35 38	80 37 12	Green's Point.....	3309.6	3. 51978
299 37 17	119 38 55	Sandy Point.....	3918.1	3. 59308
31 44 02	211 42 27	Pine Hill.....	6316.0	3. 80044
75 21 32	255 18 32	Warwick light-house, 1863.....	6479.8	3. 81156
328 05 13	148 06 39	North Popasquash.....	5670.2	3. 75360
1 48 45	181 48 36	Pine Hill.....	10191.3	4. 00823
280 46 43	100 51 38	Mount Hope.....	10451.5	4. 01918
323 07.45	143 12 05	Quaker.....	15122.7	4. 17963
334 26 35	154 28 25	Quaker.....	8815.8	3. 94526
246 21 44	66 24 08	Mount Hope.....	5461.7	3. 73733
344 06 08	164 08 01	Quaker.....	14327.2	4. 15616
22 51 08	202 49 30	Pine Hill.....	8823.5	3. 94564
240 12 58	60 13 43	Nayatt light-house, 1863.....	1799.2	3. 25508
310 40 30	130 42 41	North Popasquash.....	6012.6	3. 77906
355 06 38	175 06 46	North Popasquash.....	3398.3	3. 53126
97 09 07	277 07 04	Connimicut.....	4301.5	3. 63362
19 59 16	199 58 32	North Popasquash.....	4512.3	3. 65440
64 59 00	244 58 07	Babcock.....	2020.8	3. 30552
208 50 37	28 51 40	Nayatt light house, 1863.....	4534.4	3. 65652
279 12 17	99 14 46	North Popasquash.....	5254.1	3. 72058
107 57 24	287 56 25	Babcock.....	2171.9	3. 33683
171 14 25	351 14 18	Hall.....	1542.1	3. 18810
12 57 44	192 57 21	North Popasquash.....	3613.1	3. 55788
82 59 53	262 59 21	Babcock.....	1107.8	3. 04448
16 40 04	196 39 18	North Popasquash.....	5608.9	3. 74888
83 05 13	263 03 00	Nayatt light-house, 1863.....	4636.8	3. 66622
342 21 51	162 22 38	North Popasquash.....	5414.5	3. 73356
75 40 26	255 39 47	Nayatt light-house, 1863.....	1399.6	3. 14601
266 09 57	86 15 28	Mount Hope.....	11525.0	4. 06164
312 16 52	132 21 48	Quaker.....	13932.2	4. 14402
278 14 24	98 19 59	Mount Hope.....	11768.7	4. 07073
34 58 26	214 56 14	High Rocks.....	8038.4	3. 90517
261 31 15	81 37 21	Mount Hope.....	12862.0	4. 10931
16 33 28	196 30 56	McSparran.....	18603.3	4. 26959
335 59 58	156 03 20	Quaker.....	17311.3	4. 23833
60 37 47	240 33 10	Whitman.....	11069.8	4. 04414
233 00 40	53 05 41	Mount Hope.....	13130.8	4. 11829
283 34 10	103 38 36	Quaker.....	9562.7	3. 98058

## NARRAGANSETT BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Pojack.	° / '' 41 39 04.92	151.8	° / '' 71 24 27.97	647.2
Warren Spire.	41 43 48.47	1495.3	71 17 04.14	95.7
Bristol court-house.	41 40 12.66	390.6	71 16 25.67	593.8
Wickford Spire.	41 34 23.40	721.9	71 27 00.02	0.5
Wickford light-house. 1843.	41 34 15.92	491.1	71 26 22.64	524.6
Patience.	41 39 33.47	1032.6	71 21 24.58	568.7
Apponaug spire.	41 41 55.84	1722.7	71 27 30.08	695.6
Hog Island.	41 38 40.38	1245.7	71 16 50.58	1170.4
Castle Island Beacon. 1843.	41 39 13.97	431.0	71 17 12.20	282.3
Castle Hill.	41 27 53.02	1635.7	71 21 28.80	668.3
Fox Island.	41 33 16.24	501.0	71 25 04.48	103.8
Dyer's Island.	41 34 57.25	1766.2	71 17 55.49	1285.4
Goat Island light-house. 1843.	41 29 36.09	1113.4	71 19 39.10	907.0
Poorhouse belfry.	41 30 26.86	828.6	71 19 43.31	1006.5
Fort Adams, flagstaff. 1843.	41 28 47.51	1465.7	71 20 14.24	330.4
Gould Island.	41 32 04.30	132.7	71 20 42.02	974.1
South Rock.	41 34 26.66	822.5	71 25 03.67	85.0
Halfway Rock.	41 33 49.82	1537.0	71 19 58.34	1351.8
Beavertail light-house. 1839-'43.	41 26 56.86	1754.2	71 23 59.42	1379.3
Rose Island.	41 29 48.20	1487.0	71 20 34.44	798.8
Prince.	41 44 34.61	1067.7	71 18 56.22	1299.0
Reynolds.	41 33 45.55	1405.2	71 26 52.10	1207.2
Sherman's house, chimney.	41 33 47.42	1462.9	71 22 24.25	561.9

## NARRAGANSETT BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
124 42 23	304 40 29	Whitman .....	4822. 5	3. 68327
259 44 36	79 51 16	Mount Hope.	14145. 6	4. 15062
29 04 31	208 57 39	McSparran .....	29688. 6	4. 47259
67 13 21	247 06 32	Whitman.	15469. 6	4. 18948
261 26 23	81 27 42	Mount Hope .....	2794. 5	3. 44630
350 53 24	170 54 09	Quaker.	9851. 0	3. 99348
3 50 43	183 50 27	McSparran .....	8547. 9	3. 93186
266 14 46	86 22 32	Quaker.	16289. 2	4. 21190
9 50 54	189 50 13	McSparran .....	8421. 5	3. 92539
101 01 23	281 00 17	Wickford.	2361. 6	3. 37320
260 25 56	80 30 34	Mount Hope .....	9813. 9	3. 99184
315 05 56	135 10 00	Quaker.	12018. 2	4. 07984
307 15 07	127 23 13	Quaker .....	21294. 6	4. 32827
354 23 59	174 24 06	Whitman.	2540. 4	3. 40491
225 39 21	45 40 57	Mount Hope .....	4668. 7	3. 66920
342 44 59	162 46 00	Quaker.	7203. 4	3. 85754
341 34 39	161 35 55	Quaker .....	8343. 1	3. 92133
239 52 35	59 54 26	Mount Hope.	4438. 0	3. 64719
113 05 22	293 01 26	McSparran .....	8975. 1	3. 95304
252 57 27	72 58 54	Hazard.	3184. 5	3. 50304
119 03 13	299 01 14	Wickford .....	4723. 0	3. 67422
228 02 03	48 09 07	Mount Hope.	19856. 4	4. 29790
52 09 12	232 06 06	Batty .....	8241. 2	3. 91599
205 30 08	35 32 27	Mount Hope.	11243. 7	4. 05091
217 14 33	37 15 14	Miantonony .....	2362. 9	3. 37344
347 28 32	167 28 46	Hazard.	2301. 8	3. 36206
258 21 59	78 22 43	Miantonony .....	1559. 8	3. 19306
351 06 14	171 06 31	Hazard.	3859. 9	3. 58658
213 35 44	33 36 48	Miantonony .....	4057. 6	3. 60827
299 38 44	119 39 22	Hazard.	1512. 7	3. 17976
199 00 42	19 02 01	Prudence .....	8488. 5	3. 92883
265 28 01	85 31 08	Slate.	6566. 0	3. 81730
320 17 23	140 19 01	Batty .....	5349. 5	3. 72831
20 46 04	200 44 30	McSparran.	9227. 8	3. 96510
50 51 37	230 49 52	Batty .....	4718. 6	3. 67381
342 29 29	162 30 23	Miantonony.	6235. 8	3. 79489
86 49 38	266 46 36	Meeting-house Hill .....	6382. 2	3. 80497
137 46 58	317 44 42	McSparran.	7087. 6	3. 85050
89 48 21	269 43 49	McSparran .....	9517. 0	3. 97850
325 46 02	145 46 53	Hazard.	3169. 6	3. 50100
320 49 12	140 52 11	Mount Hope .....	9886. 0	3. 99502
57 29 25	237 23 50	Whitman.	13800. 7	4. 13990
230 41 46	50 43 25	Quonsett 3 .....	4457. 0	3. 64904
295 18 28	115 21 18	Hull.	6560. 8	3. 81696
135 06 06	315 04 47	Quonsett 3 .....	3903. 2	3. 59142
5 32 04	185 31 56	Hull.	2878. 3	3. 45913

## NARRAGANSETT BAY—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
School-house, chimney.	41 32 18.25	563.0	71 22 33.32	772.3
Barn, cupola.	41 32 08.72	269.0	71 22 36.98	857.3
Dutch Island, flagstaff. 1868.	41 30 19.30	595.4	71 24 04.75	110.2
Potter's windmill, shaft.	41 30 56.30	1736.9	71 22 28.66	664.6
Dutch Island light-house. 1868.	41 29 48.28	1489.5	71 24 17.18	398.5
Narragansett church.	41 29 33.60	1036.6	71 25 33.46	776.2
Tefft's barn, cupola.	41 31 32.92	1015.6	71 25 34.92	809.6
Hamilton Mills, cupola.	41 32 57.49	1773.6	71 26 17.05	395.2
Sanford's Mill, cupola.	41 33 05.93	182.9	71 26 53.50	1239.9
Fox Island, house chimney.	41 33 15.00	462.8	71 25 06.59	152.7
Wickford Academy.	41 34 06.68	206.1	71 27 21.19	491.0
Wickford Baptist church.	41 34 19.58	604.1	71 27 05.35	123.9
Fish House, chimney.	41 34 41.97	1294.8	71 26 51.84	1200.9
Smith's barn, cupola.	41 36 00.02	0.6	71 25 23.04	533.6
Wickford light-house. 1868.	41 34 15.92	491.1	71 26 22.59	523.4
Green's barn, cupola.	41 33 42.34	1306.2	71 26 31.25	724.1
Vaughn's house, cupola.	41 34 25.62	790.4	71 27 45.68	1058.3
Poor-house, northeast gable.	41 35 21.98	678.1	71 24 50.76	1175.7
Browning's house, chimney.	41 32 00.82	25.3	71 25 49.54	1148.5
Signal flag.	41 35 32.16	992.1	71 25 42.20	977.4
Boston Neck.	41 28 19.08	588.6	71 26 05.43	126.0
Prudence Island light-house. 1861.	41 36 21.34	658.4	71 18 14.46	334.9

## NARRAGANSETT BAY—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
75 45 15	255 43 19	Barber's Heights -----	4180. 6	3. 62124
155 13 53	335 12 40	Quonsett 3. -----	6074. 9	3. 78354
79 30 36	259 28 42	Barber's Heights -----	4034. 6	3. 60580
157 03 00	337 01 50	Quonsett 3. -----	5309. 6	3. 80000
177 20 11	357 19 59	Quonsett 3 -----	9195. 2	3. 96356
209 59 14	30 00 13	Hull. -----	4105. 6	3. 61338
109 49 26	289 47 27	Barber's Heights -----	4422. 1	3. 64563
175 50 38	355 50 33	Hull. -----	2420. 9	3. 38398
155 26 14	335 25 27	Barber's Heights -----	3955. 1	3. 59716
179 12 45	359 12 41	Quonsett 3. -----	10143. 3	4. 00618
188 43 54	8 44 41	Quonsett 3 -----	10719. 4	4. 03017
219 35 48	39 37 45	Hull. -----	6446. 0	3. 80929
193 30 36	13 31 24	Quonsett 3 -----	7110. 8	3. 85192
252 45 20	72 47 19	Hull. -----	4337. 4	3. 63723
211 29 20	31 30 36	Quonsett 3 -----	5048. 7	3. 70318
284 29 18	104 31 45	Hull. -----	5287. 3	3. 72323
284 51 32	104 54 23	Hull -----	6169. 9	3. 79028
321 37 44	141 38 41	Barber's Heights. -----	3189. 3	3. 50370
194 56 35	14 57 04	Quonsett 3 -----	3896. 8	3. 59071
298 07 55	118 09 35	Hull. -----	3952. 6	3. 59688
242 13 18	62 15 16	Quonsett 3 -----	4659. 9	3. 66838
297 36 11	117 40 20	Hull. -----	7454. 9	3. 87244
244 43 24	64 45 12	Quonsett 3 -----	4153. 2	3. 61838
301 42 22	121 45 21	Hull. -----	7333. 1	3. 86529
274 46 00	94 49 01	Conanicut N -----	6323. 1	3. 80093
0 11 52	180 11 52	Reynolds. -----	1740. 4	3. 24066
304 39 57	124 41 59	Conanicut N -----	5159. 6	3. 71262
26 26 51	206 25 52	Reynolds. -----	4633. 0	3. 66586
235 42 35	55 43 54	Quonsett 3 -----	3347. 1	3. 52467
267 10 18	87 12 59	Conanicut N. -----	5630. 2	3. 75052
225 25 42	45 27 07	Quonsett 3 -----	4163. 3	3. 61944
337 59 53	158 00 35	Barber's Heights. -----	3908. 4	3. 59200
251 17 51	71 20 05	Quonsett 3 -----	4951. 5	3. 69474
327 14 46	147 16 17	Barber's Heights. -----	5895. 9	3. 77055
283 26 44	103 27 02	Quonsett 3 -----	656. 4	2. 81719
331 39 21	151 40 50	Hull. -----	6568. 7	3. 81748
198 16 53	18 17 50	Quonsett 3 -----	6375. 6	3. 80452
314 41 45	134 41 59	Barber's Heights. -----	699. 4	2. 84471
293 52 23	113 54 37	Conanicut N -----	5126. 1	3. 70979
357 19 52	177 20 01	Barber's Heights. -----	7019. 6	3. 84631
145 50 35	325 49 43	McSparran -----	3276. 2	3. 51537
50 00 19	229 58 41	Meeting-house Hill. -----	4499. 5	3. 65317
214 57 09	34 59 40	Mount Hope -----	9216. 2	3. 96455
302 24 05	122 26 02	Quaker. -----	4832. 1	3. 68414

## RHODE ISLAND AND MASSACHUSETTS BOUNDARY.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ' "		° ' "	
Beaconpole (Borden).	42 00 03.257	100.5	71 26 43.159	993.2
Red Brush, Massachusetts (C. & G. S. and Borden).	42 01 49.546	1528.7	71 22 23.459	539.6
Joe's Rock, Massachusetts (Borden).	42 01 52.99	1634.9	71 24 17.24	396.6
Great Rock, Massachusetts (C. & G. S. and Borden).	41 51 32.36	998.4	71 17 15.47	356.8
King's Rock, Massachusetts (Borden).	41 45 22.81	704.0	71 16 17.27	399.0
Munroe (Borden).	41 46 34.35	1059.8	71 19 05.61	129.6
Burnt Swamp, Massachusetts (Borden).	42 01 08.36	257.9	71 22 54.53	1254.6
Bald Hill Massachusetts (Borden).	42 02 44.22	1364.3	71 42 35.59	818.4
Alumpond, Massachusetts, (Borden).	42 01 14.51	447.7	71 45 45.24	1040.8
Mount Daniel, Massachusetts (Borden).	42 01 41.54	1281.6	71 48 10.30	236.9
Northwest corner of Rhode Island (Borden).	42 00 29.15	899.4	71 47 58.92	1355.8
Northeast corner of Connecticut (Borden).	42 01 24.82	765.8	71 48 04.20	96.6

## FROM POINT JUDITH TO KNAPP'S POINT.

Wilcox.	41 21 23.198	715.5	71 43 59.859	1391.4
Green Hill.	41 22 24.700	762.0	71 35 51.593	1199.0
Peleg Tiff.	41 23 18.746	578.4	71 48 40.418	939.0
Noyes' Point.	41 19 46.309	1428.7	71 45 19.443	452.0
Cranberry Hill.	41 20 53.226	1642.1	71 47 22.770	529.3
Joshua Champlin.	41 22 16.387	505.6	71 39 55.332	1285.8
Tiff.	41 27 48.562	1498.2	71 32 15.700	364.3
Meeting-house Hill.	41 26 45.316	1398.0	71 28 33.931	787.5
Austin.	41 24 25.282	780.0	71 28 44.899	1042.9
Weeden.	41 22 50.890	1570.0	71 33 15.241	354.4
Point Judith.	41 21 54.836	1691.8	71 29 17.941	417.0

## RHODE ISLAND AND MASSACHUSETTS BOUNDARY.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
305 28 55.0	125 38 03.8	Great Meadow -----	23244.3	4.366316
348 15 00.0	168 16 48.8	College Hill.	18415.5	4.265183
322 22 16.3	142 28 31.5	Great Meadow -----	21193.4	4.326202
58 30 07.5	238 27 01.6	Beaconpole.	7498.8	3.874993
317 20 11	137 27 42	Great Meadow -----	22963.8	4.361044
358 58 34	178 58 45	College Hill.	21420.4	4.330828
19 20 33	199 13 48	McSparran -----	42668.3	4.630105
354 56 55	174 58 13	Quaker.	30816.3	4.488780
198 13 55	18 16 05	Great Meadow -----	14369.1	4.157430
130 32 00	310 26 51	College Hill.	14066.5	4.148187
322 36 12	142 41 14	Pocasset -----	17267.9	4.237240
346 14 23	166 16 54	Quaker.	22136.4	4.345107
125 54 18	305 53 23	Joe's Rock -----	2348.4	3.370766
209 20 39	29 21 00	Red Brush.	1458.0	3.163751
282 40 55	102 51 37	Beaconpole (Borden) -----	22466.8	4.351541
274 40 34	94 53 18	Beaconpole (Borden) -----	26372.0	4.421144
237 35 26	57 37 37	Bald Hill.	5166.4	3.713189
255 51 38	75 55 31	Bald Hill -----	7935.5	3.899574
284 01 11	104 02 48	Alumpond.	3438.3	3.536350
173 17 09	353 17 01	Mount Daniel -----	2248.8	3.351960
275 40 05	95 41 38	Alumpond -----	3211.9	3.50676
164 50 30	344 50 26	Mount Daniel.	534.4	2.72786

## FROM POINT JUDITH TO KNAPP'S POINT.

329 24 30.3	149 30 06.2	Block Island -----	23323.0	4.367785
165 02 57.7	345 01 06.6	Champlin.	15098.2	4.178925
358 43 39.4	178 43 53.2	Block Island -----	21989.3	4.342211
80 33 10.8	260 27 48.1	Wilcox.	11505.8	4.060917
193 20 20.5	13 21 35.1	Champlin -----	11327.4	4.054131
125 40 31.8	305 35 14.0	Lantern Hill.	13725.1	4.137517
144 32 11.7	324 29 58.9	Peleg Tiff -----	8048.2	3.905700
211 45 12.8	31 46 05.4	Wilcox.	3515.3	3.545962
258 53 31.3	78 55 45.4	Wilcox -----	4806.8	3.681858
158 06 29.8	338 05 38.5	Peleg Tiff.	4838.4	3.684705
344 08 44.7	164 11 39.3	Block Island -----	22583.9	4.353799
58 27 35.9	238 24 01.7	Noyes' Point.	8843.5	3.946623
97 40 25.0	277 30 47.4	Champlin -----	20413.3	4.309913
8 05 19.3	188 03 10.6	Block Island.	32295.0	4.509135
110 46 50.4	290 44 23.6	Tiff -----	5504.7	3.740734
61 41 38.0	241 38 13.6	Broad Hill.	8148.6	3.911083
183 22 22.4	3 22 29.7	Meeting-house Hill -----	4327.6	3.636248
93 46 11.1	273 42 54.0	Broad Hill.	6934.5	3.841015
169 13 01.9	349 12 43.7	Broad Hill -----	3425.1	3.534672
245 05 59.4	65 08 58.1	Austin.	6922.6	3.840270
189 23 18.8	9 23 40.6	Austin -----	4704.3	3.672496
107 25 57.0	287 23 20.1	Weeden.	5779.4	3.761880



## FROM POINT JUDITH TO KNAPP'S POINT—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / //		° / //	
Point Judith light-house, 1838.	41 21 39.884	1230.4	71 28 54.732	1272.1
Sherman.	41 30 16.938	522.6	71 30 56.024	1299.2
Wilbur.	41 29 29.630	914.1	71 38 32.536	754.7
Shannock.	41 28 05.190	160.1	71 38 21.488	498.6
Kingston church spire, 1838-'69.	41 28 48.900	1508.6	71 31 33.541	778.1
Pawkhungernock church.	41 30 20.058	618.8	71 50 25.464	590.5
Block Island North light-house, 1838.	41 13 29.152	899.4	71 34 33.050	769.8
Watch Hill light-house, 1838.	41 18 13.695	422.5	71 51 32.255	750.4
Quonochontaug.	41 19 59.986	1850.7	71 42 37.329	867.9
Meetinghouse Hill 2. 1869.	41 26 43.175	1332.0	71 28 33.552	778.8
New Weeden,	41 22 54.286	1674.7	71 33 16.313	379.1
Governor's Island.	41 21 19.416	599.0	71 39 12.292	285.7
Kenyon.	41 23 25.332	781.5	71 37 01.430	33.2
Ajax.	41 20 35.864	1106.4	71 41 17.404	404.6
Bunker Hill.	41 23 10.163	313.5	71 39 16.346	379.8
Hiscox.	41 21 29.185	900.3	71 42 14.556	338.3
Noyes' Neck.	41 19 46.490	1434.2	71 45 19.841	461.4
Commons.	41 21 15.213	469.2	71 43 54.697	1271.4
Village Hill.	41 20 54.173	1671.3	71 44 59.291	1378.3
Hector.	41 19 31.659	976.7	71 47 20.571	478.4
Cranberry Hill 2. 1873.	41 20 53.397	1647.3	71 47 22.799	530.0
Achilles.	41 19 15.355	473.7	71 48 47.545	1105.8
Fort Hill.	41 20 01.266	39.1	71 49 15.129	351.8

## FROM POINT JUDITH TO KNAPP'S POINT—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
80 35 18.7	260 20 32.0	Watch Hill.....	31652.2	4.500403
187 54 33.3	7 55 32.8	McSparran.....	15170.7	4.181007
20 26 23.0	200 24 32.6	Broad Hill.....	11093.4	4.045066
85 13 12.8	265 02 42.2	Champlin.....	22155.9	4.345490
87 56 57.6	267 51 29.5	Champlin.....	11495.9	4.060544
323 00 45.7	143 03 57.5	Broad Hill.....	11184.1	4.048600
100 34 53.0	280 29 17.6	Champlin.....	11948.0	4.077295
273 25 29.1	93 29 31.3	Tiff.....	8504.1	3.929627
51 38 32.4	231 30 18.7	Wilcox.....	22123.6	4.344855
92 20 29.7	272 10 24.1	Champlin.....	21226.2	4.326872
291 21 14.1	111 23 38.4	Champlin.....	5422.6	3.734205
331 34 11.2	151 38 26.3	Wilcox.....	18827.2	4.274787
113 02 21.8	292 51 19.4	Watch Hill.....	25381.3	4.404514
13 48 28.3	193 47 50.4	Block Island.....	5625.0	3.750121
197 23 37.0	17 23 46.9	Watch Hill.....	1171.5	3.068736
302 21 57.4	122 32 31.3	Block Island.....	26537.2	4.423855
244 37 59.8	64 42 27.9	Green Hill.....	10435.1	4.018497
330 24 24.8	150 29 06.2	Block Island.....	20139.9	4.304057
247 04 21.6	67 08 37.0	Dumplin 2.....	9716.8	3.987524
195 44 21.8	15 45 07.6	McSparran 2.....	5917.4	3.772130
75 49 09.6	255 47 27.0	Green Hill.....	3722.0	3.570778
169 18 15.0	349 17 57.5	Broad Hill.....	3317.5	3.520814
246 37 45.6	66 39 58.2	Green Hill.....	5081.0	3.705945
62 48 52.1	242 46 36.7	Quonochontaug.....	5359.9	3.729159
319 03 00.1	139 03 46.3	Green Hill.....	2476.3	3.393801
38 04 10.2	218 02 43.7	Governor's Island.....	4933.3	3.693142
245 11 43.1	65 13 05.8	Governor's Island.....	3203.9	3.505679
59 13 46.8	239 12 54.0	Quonochontaug.....	2163.0	3.335061
261 29 48.8	81 31 18.0	Kenyon.....	3169.3	3.500969
286 24 21.1	106 26 36.4	Green Hill.....	4960.2	3.695502
274 03 07.5	94 05 07.9	Governor's Island.....	4247.4	3.628128
10 53 36.2	190 53 21.2	Quonochontaug.....	2802.2	3.447503
263 41 53.3	83 43 40.6	Quonochontaug.....	3801.9	3.580004
78 10 36.7	258 06 40.8	Watch Hill.....	8492.5	3.929034
35 53 04.6	215 52 08.4	Noyes' Neck.....	3377.9	3.528653
322 12 49.6	142 13 40.7	Quonochontaug.....	2936.2	3.467788
296 50 48.4	116 52 22.2	Quonochontaug.....	3699.9	3.568188
12 53 29.0	192 53 15.4	Noyes' Neck.....	2142.0	3.330816
260 44 01.1	80 45 20.8	Noyes' Neck.....	2844.7	3.454031
76 51 26.6	256 48 50.4	Watch Hill.....	5652.1	3.752212
269 34 32.9	89 36 07.7	Village Hill.....	3336.4	3.523274
358 49 22.1	178 49 23.6	Hector.....	2522.1	3.401765
258 44 04.7	78 46 21.9	Noyes' Neck.....	4925.0	3.692405
77 18 58.3	257 17 19.5	Watch Hill.....	3568.1	3.552439
288 54 49.8	108 56 05.4	Hector.....	2816.2	3.449669
52 13 49.6	232 12 29.0	Watch Hill.....	3592.0	3.555339

## FROM POINT JUDITH TO KNAPP'S POINT—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Frost, Connecticut.	° / '' 41 20 57.572	1776.0	° / '' 71 51 03.250	75.6
Watch Hill light-house, 1873-'86.	41 18 14.192	437.8	71 51 32.432	754.6
Eel's Hill 2, Connecticut. 1838.	41 22 49.868	1538.4	71 51 04.352	101.1
Montauk 2, New York. 1874.	41 03 54.383	1677.7	71 54 18.505	432.0
Paine.	41 09 18.853	581.6	71 33 44.990	1049.0
Block Island north light-house, 1874.	41 13 39.660	1223.4	71 34 34.736	809.1
Block Island (southeast) light-house, 1875.	41 09 10.120	312.2	71 33 08.391	195.6
James.	41 32 41.81	1289.8	71 39 52.97	1227.6
Bushy Hill.	41 12 43.99	1357.0	71 33 40.56	944.9
Tower Hill church.	41 28 02.85	87.9	71 27 35.23	817.5
Big Hill.	41 23 26.36	813.3	71 46 08.49	197.3
Wells' Hill.	41 25 56.65	1747.7	71 45 15.92	369.6
Diamond Hill, tree.	41 25 46.62	1438.3	71 46 28.73	667.0
Cormorant Hill.	41 23 37.22	1148.2	71 49 03.45	80.2
Sugar Loaf Hill.	41 26 04.96	153.1	71 30 40.02	929.1
Wakefield flagstaff.	41 26 05.03	155.1	71 30 40.05	929.9
Wakefield church, white spire.	41 26 24.25	748.2	71 30 11.06	256.7
Wakefield church, gray spire	41 26 25.58	789.2	71 29 50.95	1182.8
Peirce's barn, cupola.	41 25 34.08	1051.4	71 28 50.74	1178.1
Block Island, derrick.	41 09 10.01	308.8	71 33 08.80	205.2
Sandhill.	41 21 40.62	1253.2	71 42 17.39	404.2
White house, west chimney.	41 23 20.46	631.2	71 29 18.66	433.6
Sherman's (J. P.) house, center chimney.	41 23 25.18	776.8	71 31 45.62	1059.9

## FROM POINT JUDITH TO KNAPP'S POINT—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ' "	° ' "		<i>Metres.</i>	
304 38 01.8	124 39 13.2	Fort Hill .....	3055.6	3.485095
4 42 40.8	184 42 31.6	Watch Hill.	3951.0	3.596705
187 39 57.9	7 40 17.3	Frost .....	5085.7	3.706351
224 01 10.6	44 02 41.4	Fort Hill.	4594.5	3.662237
138 42 24.9	318 38 42.3	Lantern Hill .....	11833.3	4.073108
206 32 46.3	26 35 36.1	Champlin.	13318.8	4.124466
188 40 43.8	8 42 43.2	Watch Hill .....	27947.9	4.446349
244 53 56.6	65 06 18.3	Block Island.	29031.3	4.462867
70 56 10.1	250 42 39.1	Montauk 2 .....	30471.9	4.483899
132 31 57.8	312 30 48.2	Block Island.	3342.1	3.524013
56 55 18.4	236 42 19.5	Montauk 2 .....	32985.2	4.518320
12 41 29.9	192 40 53.1	Block Island.	5931.6	3.773168
71 55 20.9	251 41 25.9	Montauk 2 .....	31195.1	4.494086
127 19 59.9	307 18 26.3	Block Island.	4170.2	3.620162
56 36 34	236 31 59	Champlin .....	11525.2	4.06165
15 19 54	195 17 11	Wilcox.	21705.5	4.33657
114 45 02	294 33 25	Watch Hill .....	27063.9	4.43239
32 14 10	212 12 58	Block Island.	4810.3	3.68217
86 09 06	266 06 00	Tiff .....	6523.6	3.81449
18 52 41	198 47 27	Block Island.	34250.0	4.53466
86 12 36	266 10 56	Peleg Tiff .....	3537.6	3.54871
20 04 51	200 04 02	Cranberry Hill.	5029.7	3.70154
44 17 46	224 15 31	Peleg Tiff .....	6803.5	3.83273
14 45 32	194 44 57	Big Hill.	4794.4	3.68073
33 51 20	213 49 53	Peleg Tiff .....	5492.2	3.73975
353 47 56	173 48 09	Big Hill.	4352.3	3.63872
62 32 10	242 30 50	Eel's Hill 2 .....	3166.3	3.50055
316 47 47	136 48 02	Peleg Tiff.	781.7	2.89303
248 06 52	68 08 16	Meetinghouse Hill 2 .....	3163.8	3.50021
213 25 47	33 27 56	McSparran 2.	8238.4	3.91584
213 29 16	33 31 25	McSparran .....	8210.8	3.91438
246 59 19	67 00 42	Meetinghouse Hill.	3180.7	3.50253
255 31 45	75 32 50	Meetinghouse Hill 2 .....	2337.8	3.36881
48 29 45	228 29 26	Sugar Loaf Hill.	897.7	2.95312
253 11 03	73 11 54	Meetinghouse Hill 2 .....	1877.0	3.27347
60 49 58	240 49 26	Sugar Loaf Hill.	1304.7	3.11550
190 36 17	10 36 28	Meetinghouse Hill 2 .....	2168.5	3.33615
110 35 24	290 34 12	Sugar Loaf Hill.	2710.3	3.43302
71 55 22	251 41 26	Montauk 2 .....	31184.6	4.49394
127 27 07	307 25 34	Block Island.	4164.6	3.61957
77 17 45	257 16 37	Wilcox .....	2441.7	3.38770
8 29 52	188 29 39	Quonochontaug.	3138.8	3.49676
79 21 55	259 17 35	Green Hill .....	9291.2	3.96807
111 48 21	291 45 26	Broad Hill.	6608.6	3.82011
65 40 25	245 39 25	New Weeden .....	2312.8	3.36413
130 17 05	310 15 48	Broad Hill.	3568.5	3.55248

## FROM POINT JUDITH TO KNAPP'S POINT—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Topographical pole 4.	° / '' 41 23 59.28	1828.8	° / '' 71 32 40.78	947.3
Hazard's (A. P.) house, center chimney.	41 24 34.68	1069.9	71 33 04.20	97.6
Topographical pole 6.	41 24 00.68	21.0	71 33 31.32	727.5
Browning's (W. T.) house, center chimney.	41 23 12.44	383.8	71 34 36.28	843.0
Topographical pole 3.	41 23 17.94	553.4	71 35 17.72	411.7
Topographical pole, near post-road.	41 23 41.82	1290.1	71 35 54.60	1268.5
Seventh-Day meeting house, north chimney.	41 23 36.04	1111.8	71 36 30.00	697.0
Kenyon's (H. G.) house, center chimney.	41 22 56.41	1740.2	71 37 06.67	155.0
Liberty pole.	41 21 41.54	1281.5	71 37 21.90	509.0
Border Hill, topographical pole.	41 23 26.74	824.9	71 38 29.70	690.0
Yellow barn, cupola.	41 22 31.40	968.7	71 37 26.60	618.1
Harris' barn, east cupola.	41 22 19.74	609.0	71 40 22.64	526.1
Westerly.	41 21 59.88	1847.3	71 40 52.84	1228.1
Davis' (O.) house, east gable chimney.	41 20 56.91	1755.6	71 44 09.26	215.3
Brown's (E.) house, chimney.	41 19 54.22	1672.7	71 45 25.62	595.8
Bentley.	41 21 51.91	1601.4	71 45 33.28	773.4
Nye's (R.) house, white chimney.	41 21 54.53	1682.3	71 46 28.12	653.5
Knapp's Point, house chimney.	41 18 22.53	695.1	71 53 07.63	177.5
Dunn's house, white chimney.	41 21 06.38	196.8	71 46 07.44	172.9
Sanders' (E.) house, chimney.	41 20 26.32	812.0	71 44 46.60	1083.4
Hazard's Castle.	41 24 55.10	1699.9	71 27 28.37	658.9
Wharton's (Dr.) house, east chimney.	41 24 56.65	1747.7	71 27 16.49	382.9

## FROM POINT JUDITH TO KNAPP'S POINT—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° / "	° / "		<i>Metres.</i>	
56 40 03	236 37 57	Green Hill -----	5307. 4	3. 72488
131 03 14	311 02 33	Broad Hill.	1910. 9	3. 28124
5 11 36	185 11 28	New Weeden -----	3109. 8	3. 49273
44 08 23	224 06 32	Green Hill.	5586. 0	3. 74710
47 45 24	227 43 51	Green Hill -----	4403. 3	3. 64378
167 34 08	347 34 00	Broad Hill.	1240. 7	3. 09366
49 55 28	229 54 38	Green Hill -----	2287. 3	3. 35933
96 44 20	276 42 44	Kenyon.	3395. 8	3. 53094
25 36 20	205 35 58	Green Hill -----	1821. 5	3. 26042
95 24 41	275 23 32	Kenyon.	2420. 3	3. 38387
358 19 03	178 19 05	Green Hill -----	2380. 2	3. 37662
71 51 46	251 51 02	Kenyon.	1633. 8	3. 21321
337 55 14	157 55 39	Green Hill -----	2374. 9	3. 37564
65 39 56	245 39 35	Kenyon.	801. 3	2. 90379
187 46 28	7 46 31	Kenyon -----	900. 3	2. 95441
299 16 37	119 17 27	Green Hill.	2000. 3	3. 30109
188 27 01	8 27 15	Kenyon -----	3237. 1	3. 51016
237 36 11	57 37 11	Green Hill.	2485. 7	3. 39544
271 12 12	91 13 10	Kenyon -----	2051. 6	3. 31209
297 30 02	117 31 47	Green Hill.	4142. 5	3. 61726
199 21 47	19 22 04	Kenyon -----	1763. 6	3. 24639
275 20 24	95 21 27	Green Hill.	2217. 4	3. 34585
318 41 14	138 42 00	Governor's Island -----	2477. 1	3. 39394
21 40 20	201 39 44	Ajax.	3447. 9	3. 53756
298 05 41	118 06 47	Governor's Island -----	2649. 5	3. 42317
12 25 04	192 24 48	Ajax.	2653. 9	3. 42389
249 30 46	69 32 02	Hiscox -----	2846. 3	3. 45428
309 23 50	129 24 51	Quonochontaug.	2766. 4	3. 44191
236 34 37	56 36 43	Hiscox -----	5321. 1	3. 72600
267 22 57	87 24 48	Quonochontaug.	3917. 2	3. 59297
336 04 48	156 05 10	Village Hill -----	1948. 4	3. 28968
54 40 27	234 39 15	Cranberry Hill 2.	3120. 8	3. 49427
312 01 50	132 02 49	Village Hill -----	2780. 4	3. 44410
33 58 57	213 58 21	Cranberry Hill 2.	2274. 0	3. 35679
211 09 07	31 10 29	Frost -----	5589. 6	3. 74738
251 46 20	71 47 33	Watch Hill.	2704. 3	3. 43206
209 28 58	29 29 21	Bentley -----	1613. 5	3. 20776
283 22 00	103 22 45	Village Hill.	1628. 4	3. 21176
218 38 47	38 39 21	Commons -----	1931. 7	3. 28595
285 06 31	105 07 56	Quonochontaug.	3113. 5	3. 49325
115 51 31	295 49 24	Sugar Loaf Hill -----	4944. 6	3. 69413
226 15 27	46 18 59	Dumplin 2.	10294. 1	4. 01259
151 26 12	331 25 21	Meeting-house Hill 2 -----	3741. 7	3. 57306
178 50 11	358 50 06	McSparran 2.	8983. 2	3. 95343



## APPENDIX No. 9.

RESULTS DEDUCED FROM THE GEODETIC CONNECTION OF THE YOLO BASE LINE WITH THE PRIMARY TRIANGULATION OF CALIFORNIA. ALSO A REDUCTION AND ADJUSTMENT OF THE DAVIDSON QUADRILATERALS FORMING PART OF THAT TRIANGULATION.

By CHARLES A. SCHOTT, Assistant.

### PREFATORY NOTE.

In this paper on the results of higher geodesy as applied to the primary triangulation of California, Assistant Schott has given a full exposition of the method employed on the Survey for the computation of triangulation of the first order, and a more complete explanation than has heretofore been presented of the manner in which weights are applied to observed directions.

Appendix No. 14, Report for 1864, gives an account of the method as then introduced by Mr. Schott and used by him for discussing the results of the geodetic connection of the Epping base with the primary triangulation of the New England States.

In the paper now presented two new steps are introduced not believed to have been hitherto taken in any triangulation, viz, the introduction of a correction to latitudes for curvature of the vertical, and the reduction of horizontal directions to the sea-level of the station observed upon. These reductions required a knowledge of the heights of the stations already given in Appendix No. 10, Report for 1884. The introduction of these refinements was justified by the magnitude and accuracy of the work.

COMPUTING DIVISION,  
COAST AND GEODETIC SURVEY OFFICE,  
*December 31, 1885.*

Up to the present time the geographical positions on the charts published by the Survey of the region about San Francisco depended upon two preliminary base lines, measured respectively in 1851 and 1853, and upon a series of triangles covering the immediate coast line. This work was executed principally by the late Assistant R. D. Cutts. When later it became necessary to provide for a more comprehensive scheme of triangulation, which was not only to satisfy the requirements of the western coast but also to form a part of that grander scheme of the geodetic connection of the surveys of the Atlantic and Pacific coasts, the western part of the work was placed in charge of Assistant George Davidson, under whom it has been prosecuted from 1876 to the present time. In December, 1884, the field-work was so far complete as to admit of the introduction of the primary base line measured by him in 1881 in Yolo County, in the valley of the Sacramento River, and to compute and adjust that part of the triangulation known as the Davidson quadrilaterals, also to connect the same with this base and introduce the astronomical determinations, so as to form standard geodetic data to answer for the main and subordinate triangulations of California, as well as for its extension across Nevada into Utah. It is proposed to give a tolerably complete account of the computations, in view of the importance of the work, and to take this opportunity of exhibiting the method adopted by the Survey in dealing with the reduction of first-class field-work, possessing an accuracy and magnitude not surpassed anywhere. It is, however,

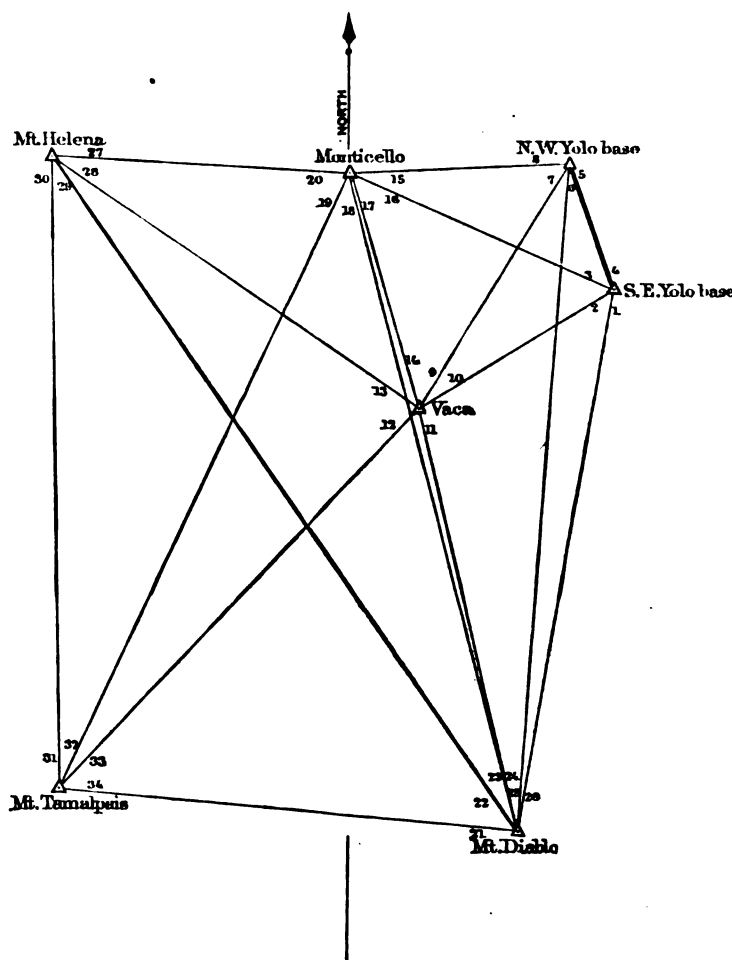


with that step only which effects the ascent from the base to the first primary line that we are here chiefly concerned.

Referring to plate No. 16 of this Report, entitled "Progress of the Transcontinental Triangulation," it is intended to deduce the length and probable error of the primary side "Mount Helena to Mount Diablo," California, as derived from the Yolo base-measure and from the angular measures at the connecting triangulation points, and which it is the immediate object of our paper to exhibit; next, to do the same for the primary side "Mount Nebo-Tushar," Utah, as derived from the Utah Valley base (as yet unmeasured); and finally to compute or adjust as a whole the primary triangulation intervening between these sides and stretching over California across Nevada to the middle of Utah, a distance but little short of 600 statute miles (or about 950 kilometres), from Mount Helena, California, to Mount Nebo, Utah.

The accompanying figure was taken from the plate referred to, and shows that the connection of the base with the primary side is made through a well-shaped or well-conditioned figure decomposable into several quadrilaterals, and having a compact area with Vaca as a central station. The length of the base\* is, roughly,  $10\frac{3}{4}$  statute miles, or about  $17\frac{1}{2}$  kilometres, and the length of the primary side is nearly 67 statute miles, or  $107\frac{3}{4}$  kilometres. Every one of the trigonometrical points is an astronomical station for latitude and azimuth, as are also the adjacent primary stations, Mount Lola and Round Top.

Two theodolites were used in the measure of the horizontal directions; diameters of graduation, 20 inches (50 cm.). They are provided with three reading microscopes, and have an eye-piece micrometer for repeating the pointings in connection with the same circle reading. The horizontal circle was used in twenty-three positions, and ordinarily between two and three series were taken in each position of the circle, each series consisting of pointings and readings of each object in succession and in the direction of increasing circle readings, with reversal of the telescope (the same pivot remaining in contact with the same Y it rested on before reversal), and followed by similar successive observations of the objects in a direction the *reverse* of that first used. After the several ocular pointings were reduced to a mean value and the circle readings were corrected for run of screw of microscopes, the measures of the various series were adjusted to give the most probable values of the several directions, together with their probable errors. This station or local adjustment was made in accordance with Bessel's method developed in his "Gradmessung," published in 1838, but stopping short at the point where the local weight-equations are formed, which it



\* See Appendix No. 11, Coast and Geodetic Survey Report for 1863.

was not proposed to carry over to the general figure adjustment—an essential difference presently again to be referred to. An account of the local adjustment of observed directions is given in Appendix No. 33, Coast Survey Report for 1854, pages 71–76, and in many later works;\* hence there appears to be no need for repeating it here. The probable error of a single measure of a direction (i. e., the mean value derived from series, telescope direct, motion forward, and series telescope reversed, motion backward) is found by

$$e_1 = \sqrt{\frac{0.455 \sum \Delta^2}{n - s - d + 1}}$$

where  $\sum \Delta^2$  = the sum of squares of differences,†  $n$  = number of observations,  $s$  = number of series, and  $d$  = number of directions. The probable error of a resulting direction is

$$e_1 = \sqrt{\frac{0.455 \sum \Delta^2}{(s - 1) (\text{diagonal coefficient})}}$$

All the pointings were on heliotropes. To the following abstract of resulting directions and their probable errors at each station, there has been added a further correction for elevation of the observed object above the sea horizon, and due to the non-intersection of the verticals in the same point of the axis of the spheroid; this correction‡ is:  $\frac{e^2}{2} \cdot \frac{h}{R} \sin 2\alpha \cos^3 \varphi$ , where  $e^2 = \frac{a^2 - b^2}{a^2}$ ,  $h$  = the elevation of the observed point,  $R$  = the radius of curvature in the plane perpendicular to the meridian,  $\varphi$  = the latitude of the station occupied, and  $\alpha$  = the azimuth of the line of sight counted from south in the direction of west to 360°. For the Clarke spheroid of 1866 and the vicinity of the parallel of 39° we have  $\log e^2 = 7.8305$  and  $\log R = 6.8054$ , and dividing the expression by  $\sin 1''$  we have with sufficient accuracy the correction in seconds  $0''.000109 \sin 2\alpha \cos^3 \varphi \cdot h$ , where  $h$  is expressed in metres; hence, finally,  $0''.000066 \sin 2\alpha \cdot h$ . The heights of the stations are given in Appendix No. 10, Coast and Geodetic Survey Report for 1884.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation.§*

SOUTHEAST BASE. Occupied in 1880 with theodolite No. 115. G. Davidson, observer.

Object.	Resulting direction.	Probable error.	Reduction to sea-level.	Resulting seconds.
	° ' "	"	"	"
Northwest base.	0 00 00.000	±0.043	−.002	59.998
Marysville Butte.	15 32 39.320	.085	−.002	39.318
Pine Hill.	89 51 47.540	.069	+ .023	47.563
Mount Diablo.	204 49 35.777	.085	+ .021	35.798
Vaca.	252 41 55.204	.079	+ .045	55.249
Monticello.	310 54 36.564	.074	−.046	36.518

\* For instance: T. W. Wright's *Treatise on the Adjustment of Observations*, New York, 1884, Article 146; Dr. W. Jordan's *Vermessungskunde*, 1878, Vol. II, § 38; Col. Clarke's *Geodesy*, Oxford, 1880, Chapter IX, Article 8.

† See Coast Survey Report for 1864, App. No. 14, pp. 120–123. In the formulæ (p. 122) for the probable error of a resulting direction the substitution of  $s - 1$  for  $s$  will give a more correct value.

‡ See for instance Clarke's *Geodesy*, p. 113, and Jordan's *Geodesy*, Vol. II, p. 317.

§ These abstracts include some directions to secondary objects which entered into the adjustment, but they omit all subordinate directions as irrelevant to the present purpose.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation—Continued.*

NORTHWEST BASE. Occupied in 1880 with theodolite No. 115. G. Davidson, observer.

Object.	Resulting direction.	Probable error.	Reduction to sea-level.	Resulting seconds.
	° ' "	"	"	"
Southeast base.	0 00 00.000	±0.038	— .001	59.999
Mount Diablo.	20 04 24.623	.080	+ .008	24.631
Vaca.	47 20 34.153	.067	+ .042	34.195
Monticello.	103 42 21.384	.059	+ .007	21.391
Marysville Butte.	200 07 47.730	.075	+ .005	47.735
Pine Hill.	283 13 29.522	.069	+ .005	29.527

VACA. Occupied in 1880 with theodolite No. 115. G. Davidson, observer.

Southeast base.	0 00 00.000	±0.064	+ .001	00.001
Pine Hill.	12 12 58.103	.080	+ .029	58.132
Mount Diablo.	109 03 23.738	.083	— .040	23.698
Mount Tamalpais.	166 20 42.497	.107	+ .052	42.549
Mount Helena.	248 47 11.185	.103	— .082	11.103
Monticello.	288 18 44.230	.108	— .032	44.198
Marysville Butte.	318 15 04.533	.098	+ .020	04.553
Northwest base.	334 38 38.711	.073	+ .003	38.714

MONTICELLO. Occupied in 1880 with theodolite No. 115. G. Davidson, observer.

Mount Helena.	0 00 00.000	±0.052	— .003	59.997
Marysville Butte.	116 50 54.208	.073	+ .035	54.243
Pine Hill.	175 09 43.409	.053	+ .005	43.414
Northwest base.	175 30 36.288	.051	.000	36.288
Southeast base.	202 42 51.850	.084	— .001	51.849
Vaca.	252 48 57.254	.066	— .026	57.228
Mount Diablo.	253 17 07.113	.107	— .041	07.072
Mount Tamalpais.	292 27 41.105	.062	+ .039	41.144

MOUNT DIABLO. Occupied in 1876 with theodolite No. 5. G. Davidson, observer. Re-occupied in 1884 with theodolite No. 115. R. A. Marr, observer (G. D., chief of party).

Mount Helena.	0 00 00.000	±0.066	— .082	59.918
Monticello.	20 03 30.643	.090	— .032	30.611
Vaca.	20 19 59.505	.098	— .024	59.481
Azimuth mark.	25 49 17.204	{ .092 .074† }	— .010	17.194
Northwest base.	38 39 09.129	.115†	.000	09.129
Marysville Butte.	38 40 30.881	.094	+ .005	30.886
Southeast base.	43 24 20.921	.106†	.000	20.921

NOTE.—The directions marked by a † depend on the probable error ±".074 of the azimuth mark during the second occupation.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation—Continued.*

## MOUNT DIABLO—Continued.

Object.	Resulting direction.	Probable error.	Reduction to sea-level.	Resulting seconds.
	° ' "	"	"	"
Lola.	73 06 31.834	±0.089	+ .178	32.012
Pine Hill.	76 14 00.524	.106	.041	00.565
Round Top.	97 32 04.551	.107	+ .174	04.725
Macho.	180 16 12.207	.111†	— .078	12.129
Mount Bache or Loma Prieta.	211 22 06.404	.084†	----	----
Sierra Morena.	249 16 39.858	.092†	----	----
Mount Tamalpais.	310 12 09.226	.095	— .008	09.218
Ross Mountain.	339 08 13.637	.087†	----	----

MOUNT HELENA. Occupied in 1876 with theodolite No. 5. G. Davidson and W. Eimbeck, observers.

Mount Diablo.	0 00 00.000	±0.058	— .073	59.927
Mount Tamalpais.	33 43 57.142	.071	— .004	57.138
Snow Mountain, east.	208 37 44.912	.059	----	----
Azimuth mark.	225 16 49.643	.052	+ .007	49.650
Marysville Butte.	265 31 14.523	.078	+ .042	14.565
Lola.	281 54 43.341	.083	+ .137	43.478
Pine Hill.	303 14 10.280	.083	+ .004	10.284
Round Top.	305 18 41.177	.074	+ .005	41.182
Monticello.	306 46 16.071	.076	— .002	16.069
Vaca.	340 03 44.142	.113	— .045	44.097

MOUNT TAMALPAIS. Occupied in 1882 with theodolite No. 115. G. Davidson, observer.

Mount Diablo.	0 00 00.000	±0.053	— .011	59.989
Macho.	23 47 56.302	.064	— .068	56.234
Sierra Morena.	61 37 29.923	.076	----	----
Ross Mountain.	230 31 28.940	.030	----	----
Mount Helena.	263 31 35.075	.086	— .006	35.069
Monticello.	289 01 42.852	.072	+ .045	42.897
Vaca.	307 25 02.177	.062	+ .048	02.225

LOLA.\* Occupied in 1879 with theodolite No. 115. G. Davidson, observer.

Azimuth mark.	0 00 00.000	±0.043	— .157	59.843
Lassen's Butte.	13 22 42.494	.113	----	----
Pah-rah.	114 46 59.230	.074	----	----
Mount Como.	173 10 32.427	.082	----	----
Round Top.	212 23 00.222	.109	— .137	00.085
Pine Hill.	267 17 07.756	.084	+ .039	07.795
Mount Diablo.	271 17 55.376	.059	+ .075	55.451
Mount Helena.	300 07 03.738	.059	+ .062	03.800
Marysville Butte.	311 51 09.936	.094	+ .016	09.952
Snow Mountain, east.	321 58 42.323	.073	----	----
Mount Linn.	340 58 41.684	.086	----	----

\* This station was added to complete the resulting data for the Davidson quadrilaterals.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation—Continued.*

ROUND TOP.\* Occupied in 1879 with theodolite No. 115. G. Davidson, observer.

Object.	Resulting direction.	Probable error.	Reduction to sea-level.	Resulting seconds.
	° ' "	"	"	"
Azimuth mark.	0 00 00.000	±0.032	— .159	59.841
Lola.	7 25 05.518	.062	— .119	05.399
Mount Como.	76 26 26.411	.060	----	----
Mount Grant.	122 47 32.511	.078	----	----
Mount Conness.	169 47 29.608	.068	----	----
Macho.	254 03 23.038	.053	+ .082	23.120
Mount Diablo.	270 44 49.863	.051	+ .062	49.925
Mount Helena.	298 32 16.332	.065	— .003	16.329
Pine Hill.	301 58 42.947	.061	— .006	42.941
Snow Mountain, east.	316 57 47.335	.047	----	----
Marysville Butte.	319 00 33.594	.069	— .029	33.565

\* This station was added to complete the resulting data for the Davidson quadrilaterals.

Since the introduction (about 1847 or 1848) of the application of the method of least squares to the adjustment of the principal triangulations of the Survey, the *separate* treatment of the station adjustment from that of the figure or net adjustment has been adhered to. After the conditions subsisting between the measured directions at a station had been satisfied, these adjusted directions were simply introduced with *equal weight* in the net adjustment, the same as if they had been the direct result of observation. The method proposed by Bessel in 1838 of introducing the weight equations obtained in connection with the station adjustment into the figure adjustment, a process which complicates the reduction very considerably, has been generally followed without modification; others have preferred the more simple and, in our opinion, the better method followed by us which appears also to have been favored by Gauss, of keeping these processes separate. Our reasons for preferring the latter method (supplementing it, however, with the introduction of a special system of weights), and apart from its recommendation of greater simplicity, may be stated as follows: In the second operation or net adjustment *new* and *distinct* sources of error appear of a magnitude exceeding even the errors inherent in the first operation. It is almost the universal experience that the average corrections to the observed directions due to the net adjustment surpass in magnitude those due to the local adjustment, a fact which is explained by the presence of lateral refraction in the rays of light, the *constant* part of which deflection enters into the geometrical conditions of the net, and the *variable* part only becomes apparent in the station conditions. Besides the disturbing influence of lateral refraction, errors having their origin in the effect of local deviations of the vertical, imperfect centering of the theodolite or in slight eccentricity of the heliotrope, in outstanding systematic graduation errors of the circles, and in other causes, tend to increase the corrections needed in the geometrical treatment of the triangulation. To make these *second* corrections fully dependent on weights introduced from conditions only subsisting *locally* would seem to be of doubtful propriety; at any rate it would appear to be a sound principle to remove contradictions which had developed in observations constituting a distinct operation, and which depend on distinct sources of error, at once within the limits of that operation, and not to carry the conditions and weights into a second operation, which subjects the observed quantities to additional corrections, and which qualities depend on sources of error of a character and size different from those in the first operation. However correct the Besselian proceeding is from a theoretical point of view, there is, nevertheless, great danger that the results may be distorted by improper weights. At first, in Coast Survey practice, all directions in the net-adjustment were given equal weight, but in 1864 greater precision was attempted by the introduction of distinct weights depending mainly on the

accuracy of the local measures, but not ignoring the new conditions arising from their combination in triangles and other figures; in short, the weights to the directions were made to consist of two parts, a variable one and a constant one, the latter to be furnished by means of the combination of triangles.

Investigations of the laws of lateral refraction hitherto made are mostly confined to short lines, and a valuable contribution to our knowledge of the subject may be expected from a discussion of our observations in connection with the great primary triangulation between California and Utah. An interesting discussion on the "Influence of lateral refraction on horizontal angles" was lately (1882) published by Dr. A. Fischer.\* His general results may be summed up as follows:

The existence of lateral refraction as affecting the horizontal angular measures is proved directly and indirectly, the former by certain discrepancies in the observations, the latter by closing errors in the triangles or other figures; the influence of the distance of the observed object on the magnitude of the deviation is small; the higher the line of sight above the surface the smaller the lateral refraction may be expected to be. The principal factors determining the magnitude of the deviation are those depending on the condition of the atmosphere respecting distribution of density and temperature, both in a statical and in a dynamical sense. The lateral refraction appears to be subject to a daily variation, and he brings out the fact, from the triangulations of England and of Prussia, that the short lines are more seriously affected than the long ones, in consequence of their generally closer proximity to the ground and the consequent denser atmosphere, and recommends the *greatest* triangles possible.

With the largest triangles measurable there are the additional advantages of a smaller number of stations within a given area, and the greater accuracy with which the azimuth may be transferred from line to line. Should greater accuracy be demanded in the measures of horizontal directions than at present attained with our instruments, it may possibly be secured by a combination of day and night observations. This would eliminate the greater part of the effect which persists as a constant deviation during the time of insolation, but which lateral refraction may be supposed to change sign during the time of nocturnal radiation.

#### DETERMINATION OF WEIGHTS TO DIRECTIONS IN THE ADJUSTMENT OF THE TRIANGULATION.

By the process adopted in 1864 we require to know the relative magnitude of the observing errors (at a station) and of the combination (to triangles and polygons) errors, respectively. To this end we need the closing errors of the triangles, and consequently also a knowledge of the spherical excesses. For the computation of the length of sides of triangles we employ Legendre's theorem, extended, if required. It has been proved that spheroidal triangles, as well as spherical triangles, may be computed by means of this theorem without sensible error (Clarke's Geodesy Chapter V). It will make no difference whether the sides of the spheroidal triangle be conceived as elliptic arcs, as lines of alignment, or as geodetic lines. The following expression for the spherical excess  $\epsilon$  will apply to the largest triangles yet measured:

$$\epsilon = \frac{a b \sin C'}{2\rho \rho_1 \sin 1''} \left[ 1 + \frac{1}{24 r^2} (a^2 + b^2 + c^2) \right]$$

where  $\rho$  = radius of curvature of the meridian and  $\rho_1$  = radius of curvature in the plane perpendicular to the meridian at a point situated at the center of the triangle. The sides  $a, b, c$  are expressed in metres and the values of  $\log \rho$  and of  $\log \rho_1$  are tabulated in Appendix No. 18, Coast Survey Report for 1876.  $C'$  is the plane angle of the triangle between the sides  $a$  and  $b$ . The value of the first term is tabulated for the argument  $\varphi$  (the latitude) in Appendix No. 7, Report for 1884. The second term, involving the square of the sides (and an average radius,  $r$ ), seldom comes into use. Even in the largest triangle of the Survey, Mount Shasta, Mount Helena, Lola, whose sides are 133, 167, and 190 statute miles, respectively, or 214, 269, and 306 kilometres (nearly), the term involving the squares of the sides is but 0.00022, and when multiplied with the factor or first term, 142''.696, it becomes 0''.031; and in all cases it suffices to distribute the excess *equally* over the three angles.

\* Prussian Geodetic Institute, Berlin.

*Table of closing errors of the triangles forming the Yolo base-figure, arranged in the order of the size of the triangles.*

No.	Triangle.	$\Sigma = \text{sum of observed angles} - \pi.$	$\epsilon$	Closing error.	
				$\Sigma - \epsilon$ +	$\Sigma - \epsilon$ —
		"	"	"	"
1	Mount Diablo, Monticello, Vaca.	—0.786	0.062	----	0.848
2	Monticello, Northwest base, Southeast base.	+0.433	1.247	----	0.814
3	Vaca, Northwest base, Southeast base.	0.232	1.273	----	1.041
4	Mount Diablo, Northwest base, Southeast base.	0.624	1.350	----	0.726
5	Monticello, Northwest base, Vaca.	2.652	2.382	0.270	----
6	Vaca, Monticello, Southeast base.	2.451	2.408	0.043	----
7	Mount Helena, Monticello, Vaca.	3.892	3.113	0.779	----
8	Mount Diablo, Vaca, Northwest base.	4.196	4.018	0.178	----
9	Mount Diablo, Vaca, Southeast base.	4.588	4.095	0.493	----
10	Mount Tamalpais, Monticello, Vaca.	4.893	4.822	0.071	----
11	Mount Diablo, Mount Helena, Vaca.	2.798	5.401	----	2.603
12	Mount Diablo, Monticello, Northwest base.	6.062	6.463	----	0.401
13	Mount Diablo, Monticello, Southeast base.	6.253	6.566	----	0.313
14	Mount Tamalpais, Mount Helena, Monticello.	7.750	8.099	----	0.349
15	Mount Diablo, Mount Tamalpais, Vaca.	6.878	8.170	----	1.292
16	Mount Diablo, Mount Helena, Monticello.	7.476	8.452	----	0.976
17	Mount Tamalpais, Mount Helena, Vaca.	8.751	9.808	----	1.057
18	Mount Diablo, Mount Tamalpais, Mount Helena.	12.831	12.577	0.254	----
19	Mount Diablo, Mount Tamalpais, Monticello.	12.557	12.930	----	0.373

We have the sum of the squares of the closing errors 15.053; hence the average closing error  $\sqrt{\frac{15.053}{19}} = \pm 0''.890$  and the probable error of a direction  $\frac{0.890}{\sqrt{6}} \times 0.6745 = \pm 0''.245$ ; but in consequence of one large residual,\* 2''.603, in the above table, this average value is injuriously affected, and we prefer to reject it; we then have the probable error of a direction  $= \pm 0''.187 = e_r$ .

We next square the probable error attached to each of the thirty-four observed directions as given in the preceding abstract of measures, and find the sum of the squares equal to 0.220; hence the average probable error of an observed direction

$$\sqrt{\frac{0.220}{34}} = \pm 0''.081 = e_o.$$

Now by comparing the values of  $e_o$  and of  $e_r$  we meet with the ordinary experience that  $e_r$  is larger than  $e_o$ , in the present case more than twice as large, though the ordinary ratio is rather below  $1\frac{1}{2}$ .

The value of  $e_r$  includes the pure observing error; hence we shall have the pure combination error by the expression  $e_c = \sqrt{e_o^2 - e_r^2} = \pm 0''.169$ , which is a constant quantity for the figure under consideration, and is to be combined with every probable error of observation  $e_o$  in order to obtain the appropriate probable error and consequent weight of each direction as needed for the figure adjustment. We have

$$e^2 = e_o^2 + e_r^2; \text{ hence the weight or } \frac{1}{e^2} = \frac{1}{e_o^2 + (0.169)^2} = p.$$

\* Due to abnormal causes.

The following table contains for each direction (the numbers refer to those in the diagram) the square of the pure observing error and the reciprocal of the weight or  $\frac{1}{p}$ :

Direction number.	$e^2$	$\frac{1}{p} = e^2$	Direction number.	$e^2$	$\frac{1}{p} = e^2$	Remarks.
1	.0072	.0358	18	.0114	.0400	Ratio of minimum to maximum weight 300:418, or 1:1.4 nearly, but had we used weights depending on the station measures alone the ratio would have been 14:132, or 1:9.4 nearly, and the value of the method here adopted depends chiefly on the fact that it permits of a proper degree of equalization of the weights. At the same time it is apparent that the value of $e_0$ is somewhat uncertain, but it may vary between rather wide limits without injuriously affecting the solution.
2	62	348	19	38	324	
3	55	341	20	27	313	
4	18	304	21	90	376	
5	14	300	22	44	330	
6	64	350	23	81	367	
7	45	331	24	96	382	
8	35	321	25	132	418	
9	53	339	26	112	398	
10	41	327	27	58	344	
11	69	355	28	128	414	For convenience of computing, $\frac{100}{p}$ instead of $\frac{1}{p}$ is introduced in the adjustment now to be explained.
12	114	400	29	34	320	
13	106	392	30	50	336	
14	117	403	31	74	360	
15	26	312	32	52	338	
16	71	357	33	38	324	
17	44	330	34	28	314	

*Adjustment of a triangulation-net or of conditioned observations.*

We shall here only briefly recapitulate the leading formulæ applicable to the case, inclusive of those for computing the probable error of a function of the adjusted quantities.

Suppose we have as the direct result of observation the  $m$  quantities  $l_1 l_2 l_3 l_4 \dots$  which are connected by  $n$  conditions, and let  $x_1 x_2 x_3 x_4 \dots$  be their most probable values (to be found by applying the method of least squares); also let  $v_1 v_2 v_3 v_4 \dots$  be the corrections to the observations, so that in general  $x_i = l_i + v_i$ , and remembering that necessarily  $m > n$  in order that any adjustment may exist at all, then these conditions may be expressed by  $n$  equations of linear form, thus:

$$\begin{aligned} a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + \dots &= 0 \\ b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \dots &= 0 \\ c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + \dots &= 0 \\ \dots &\dots \end{aligned}$$

The observed values  $l_i$  will not satisfy these equations, but will exhibit discrepancies  $w_i$ , whence we write the  $n$  conditional equations

$$\begin{aligned} a_1v_1 + a_2v_2 + a_3v_3 + a_4v_4 + \dots + w_1 &= 0 \\ b_1v_1 + b_2v_2 + b_3v_3 + b_4v_4 + \dots + w_2 &= 0 \\ c_1v_1 + c_2v_2 + c_3v_3 + c_4v_4 + \dots + w_3 &= 0 \\ \dots &\dots \end{aligned}$$

where the sign of  $w_i$  is to be taken in the sense of observed value minus true value. Let  $p_1 p_2 p_3 p_4 \dots$  be the weights of the quantities  $l_1 l_2 l_3 l_4 \dots$  then the quantity  $[p.vv]$  must be made a minimum. This leads to the equations of correlates which contain the (as yet) unknown multipliers  $C_1 C_2 C_3 \dots$ . These correlate equations are:

$$\begin{aligned} p_1v_1 &= a_1C_1 + b_1C_2 + c_1C_3 + \dots \\ p_2v_2 &= a_2C_1 + b_2C_2 + c_2C_3 + \dots \\ p_3v_3 &= a_3C_1 + b_3C_2 + c_3C_3 + \dots \\ &\text{etc.} \end{aligned}$$



Substituting the values of  $v$  in the conditional equations there result the normal equations:

$$\begin{aligned} \left[ \frac{aa}{p} \right] C_1 + \left[ \frac{ab}{p} \right] C_2 + \left[ \frac{ac}{p} \right] C_3 + \dots + w_1 &= 0 \\ \left[ \frac{ab}{p} \right] C_1 + \left[ \frac{bb}{p} \right] C_2 + \left[ \frac{bc}{p} \right] C_3 + \dots + w_2 &= 0 \\ \left[ \frac{ac}{p} \right] C_1 + \left[ \frac{bc}{p} \right] C_2 + \left[ \frac{cc}{p} \right] C_3 + \dots + w_3 &= 0 \\ \dots \dots \dots \end{aligned}$$

for these we prefer to write after putting  $u = \frac{1}{p}$

$$\begin{cases} [u. aa] C_1 + [u. ab] C_2 + [u. ac] C_3 + \dots + w_1 = 0 \\ \quad + [u. bb] C_2 + [u. bc] C_3 + \dots + w_2 = 0 \\ \quad \quad + [u. cc] C_3 + \dots + w_3 = 0 \\ \quad \quad \quad + \dots \dots \dots \end{cases}$$

Solving these equations the values of  $C_i$  become known, and consequently also the values of  $v_i$  and  $x_i$ .

We have further the mean error of an observation of the weight *one*,  $m_1 = \sqrt{\frac{[pvr]}{n}}$  and the probable error of the same  $r_1 = 0.6745 \sqrt{\frac{[pvr]}{n}}$ . The sum  $[pvr]$  is found by means of the individual corrections to the observed values and is checked by the relation:  $[pvr] = -[wC]$ .

To find the weight and probable error of an adjusted value of an observation, also the weight  $P$  of any function  $F$  of the adjusted observations, we suppose

$$F = f_1 x_1 + f_2 x_2 + f_3 x_3 + f_4 x_4 + \dots$$

which function cannot contain all the  $x$ 's but only  $m - n$  of them. The coefficients  $f_i$  are found by partial differentiation,\* viz:

$$\frac{\delta F}{\delta x_1} = f_1 \quad \frac{\delta F}{\delta x_2} = f_2 \quad \frac{\delta F}{\delta x_3} = f_3 \text{ etc.}$$

We next form the sums:

$$\left[ \frac{af}{p} \right] \quad \left[ \frac{bf}{p} \right] \quad \left[ \frac{cf}{p} \right] \text{ etc.}$$

and combine these with the former normal equations, at the same time introducing a new set of indeterminate coefficients  $R_1, R_2, R_3$ , etc., in the place of the former  $C_1, C_2, C_3$ , etc. Then the requirement of the conditioned minimum leads to the following so called (by Gerling) transfer-equations:

$$\begin{cases} [u. aa] R_1 + [u. ab] R_2 + [u. ac] R_3 + \dots + [u. af] = 0 \\ \quad + [u. bb] R_2 + [u. bc] R_3 + \dots + [u. bf] = 0 \\ \quad \quad + [u. cc] R_3 + \dots + [u. cf] = 0 \\ \quad \quad \quad + \dots \dots \dots \end{cases}$$

Their solution furnishes the transfer-coefficients  $R_i$ , and consequently also the values  $F_i$  by means of the relations:

$$\begin{aligned} F_1 &= f_1 + a_1 R_1 + b_1 R_2 + c_1 R_3 + \dots \\ F_2 &= f_2 + a_2 R_1 + b_2 R_2 + c_2 R_3 + \dots \\ F_3 &= f_3 + a_3 R_1 + b_3 R_2 + c_3 R_3 + \dots \\ F_4 &= f_4 + a_4 R_1 + b_4 R_2 + c_4 R_3 + \dots \\ \text{etc.} & \dots \dots \dots \end{aligned}$$

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\* In the absence of a special letter to indicate this,  $\delta$  is here substituted.

and finally we have the reciprocal of the weight  $P$  of the function  $F$  by

$$\frac{1}{P} = [u \cdot FF]$$

also the mean error of  $F$ , or

$$m_F = \frac{m_1}{\sqrt{P}} = m_1 \sqrt{[u \cdot FF]}$$

and the probable error of  $F$ , or

$$r_F = 0.6745 m_F$$

The mean error of any one value of  $x$ , that is, of the result of any given observation after adjustment, is determined in the same way by regarding  $x_i$  as a function  $F_i$  of the observations.

*Application to the adjustment of the Yolo base-net.*

The number of conditions in the Yolo base-net is 17; of these 11 are related to angles and 6 to ratio of sides. Corrections to directions are indicated by placing the numbers within parentheses. In the log's of the sines nine places of decimals are used, and the numbers for logarithmic difference of  $1''$  are cut off at the sixth place of decimals.

*Conditional equations.*

1	(4) — (3) + (16) — (15) + (8) — (5) — 0.814 = 0
2	(3) — (2) + (10) — (14) + (17) — (16) + 0.043 = 0
3	(4) — (2) + (10) — (9) + (7) — (5) — 1.041 = 0
4	(6) — (5) + (4) — (1) + (26) — (25) — 0.726 = 0
5	(7) — (6) + (11) — (9) + (25) — (24) + 0.178 = 0
6	(3) — (1) + (18) — (16) + (26) — (23) — 0.313 = 0
7	(19) — (17) + (14) — (12) + (33) — (32) + 0.071 = 0
8	(20) — (19) + (32) — (31) + (30) — (27) — 0.349 = 0
9	(20) — (17) + (14) — (13) + (28) — (27) + 0.779 = 0
10	(24) — (22) + (29) — (28) + (13) — (11) — 2.603 = 0
11	(22) — (21) + (34) — (31) + (30) — (29) + 0.254 = 0
12	+ 1.9606 (2) — 1.3048 (3) — 0.6558 (4) + 1.9400 (5) — 3.3408 (7) + 1.4008 (8) + 0.4743 (15) — 1.7604 (16) + 1.2861 (17) + 1.046 = 0
13	+ 1.9044 (1) — 1.2486 (2) — 0.6558 (4) + 1.9400 (5) — 4.0847 (6) + 2.1447 (7) + 1.4167 (24) — 6.3593 (25) + 4.9426 (26) — 2.809 = 0
14	+ 1.9044 (1) — 3.2092 (2) + 1.3048 (3) + 1.7604 (16) — 258.7574 (17) + 256.9970 (18) + 439.1792 (23) — 444.1218 (24) + 4.9426 (26) + 198.013 = 0
15	+ 1.9044 (1) — 3.2092 (2) + 1.3048 (3) + 1.7604 (16) — 4.3015 (17) + 2.5411 (19) + 0.7609 (21) — 5.7035 (24) + 4.9426 (26) + 6.3336 (32) — 7.9444 (33) + 1.6108 (34) — 5.817 = 0
16	+ 0.7609 (21) — 5.6818 (22) + 4.9209 (24) + 4.2562 (28) — 5.8046 (29) + 1.5484 (30) + 2.1886 (31) — 3.7994 (33) + 1.6108 (34) — 3.964 = 0
17	+ 3.1922 (17) — 2.5411 (19) — 0.6511 (20) + 3.2065 (27) — 4.7549 (28) + 1.5484 (30) + 2.1886 (31) — 6.3336 (32) + 4.1450 (33) — 1.205 = 0

*Correlate equations.*

Correc- tions.	$\mu = \frac{100}{P}$	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>	C <sub>11</sub>
v <sub>1</sub>	3.58				-1		-1					
v <sub>2</sub>	3.48		-1	-1								
v <sub>3</sub>	3.41	-1	+1				+1					
v <sub>4</sub>	3.04	+1		+1	+1							
v <sub>5</sub>	3.00	-1		-1	-1							
v <sub>6</sub>	3.50				+1	-1						
v <sub>7</sub>	3.31			+1		+1						
v <sub>8</sub>	3.21	+1										
v <sub>9</sub>	3.39			-1		-1						
v <sub>10</sub>	3.27		+1	+1								
v <sub>11</sub>	3.55					+1					-1	
v <sub>12</sub>	4.00							-1				
v <sub>13</sub>	3.92									-1	+1	
v <sub>14</sub>	4.03		-1					1		+1		
v <sub>15</sub>	3.12	-1										
v	3.57	1	-1				-1					
v <sub>17</sub>	3.30		+1					-1		-1		
v <sub>18</sub>	4.00						+1					
v <sub>19</sub>	3.24							+1	-1			
v	3.13								1	+1		
v	3.76											-1
v <sub>22</sub>	3.30										-1	+1
v <sub>23</sub>	3.67						-1					
v <sub>24</sub>	3.82					-1					+1	
v	4.18				-1	+1						
v <sub>26</sub>	3.98				+1		1					
v <sub>27</sub>	3.44								-1	-1		
v <sub>28</sub>	4.14									+1	-1	
v <sub>29</sub>	3.20										+1	-1
v <sub>30</sub>	3.36								+1			+1
v <sub>31</sub>	3.60								-1			-1
v <sub>32</sub>	3.38							-1	+1			
v <sub>33</sub>	3.24							+1				
v <sub>34</sub>	3.14											+1
		-.814	+.043	-1.041	-.726	+.178	-.313	+.071	-.349	+.779	-2.603	+.254

*Correlate equations.*

$C_{12}$	$C_{13}$	$C_{14}$	$C_{15}$	$C_{16}$	$C_{17}$
	+1.9044	+ 1.9044	+1.9044		
+1.9606	-1.2486	- 3.2092	-3.2092		
-1.3048		1.3048	+1.3048		
-0.6558	-0.6558				
+1.9400	+1.9400	-----	-----	-----	-----
	-4.0847				
-3.3408	+2.1447				
+1.4008					
-----	-----	-----	-----	-----	-----
+0.4743	-----	-----	-----	-----	-----
1.7604		+ 1.7604	+1.7604		
+1.2861		-258.7574	-4.3015		+3.1922
		+256.9970			
			+2.5411		-2.5411
-----	-----	-----	-----	-----	-0.6511
			+0.7609	+0.7609	
				-5.6818	
		+439.1792			
	+1.4167	-444.1218	-5.7035	+4.9209	
-----	-6.3593	-----	-----	-----	-----
	+4.9426	+ 4.9426	+4.9426		
					+3.2065
				+4.2562	-4.7549
				-5.8046	
-----	-----	-----	-----	+1.5484	+1.5484
				2.1886	+2.1886
			+6.3336		-6.3336
			-7.9444	-3.7994	+4.1450
			+1.6108	+1.6108	
+1.046	-2.809	+198.013	-5.817	-3.964	-1.205

*Normal equations*

C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>	C
+19.35	- 6.98	+ 6.04	+ 6.04		- 6.98					
	+21.06	+ 6.75			+ 6.98	- 7.33		- 7.33		
		+19.49	+ 6.04	+ 6.70	----	----	----	----	----	----
			+21.28	- 7.68	+ 7.56					
				+21.75					- 7.37	
					+22.21	----	----	----	----	----
						+21.19	- 6.62	+ 7.33		
							+20.15	+ 6.57		+ 6.96
								+21.96	- 8.06	----
									+21.93	- 6.50
										+20.36

These equations were solved by Mr. M. H. Doolittle by the method

Resulting values of C<sub>i</sub>.

C <sub>1</sub> = + .033900	C <sub>9</sub> = + .039218
C <sub>2</sub> = + .023593	C <sub>10</sub> = + .163816
C <sub>3</sub> = + .010217	C <sub>11</sub> = + .036790
C <sub>4</sub> = + .043760	C <sub>12</sub> = + .0175652
C <sub>5</sub> = + .066122	C <sub>13</sub> = + .0002761
C <sub>6</sub> = - .011325	C <sub>14</sub> = - .000088967
C <sub>7</sub> = + .019388	C <sub>15</sub> = + .0198674
C <sub>8</sub> = + .009930	C <sub>16</sub> = + .0120203
	C <sub>17</sub> = + .0161153

Residuals are all between - .0001 and + .0001 .

*Yolo base-net.*

C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>15</sub>	C <sub>16</sub>	C <sub>17</sub>	
- 6.632 <sub>1</sub>	- 7.8136	+ 1.8353	+ 1.8353			- 0.814 = 0
- 0.7435	+ 4.3451	- 844.5667	- 4.8622		+ 10.5343	+ 0.043 = 0
-25.6946	+ 3.6305	+ 11.1680	+ 11.1680			- 1.041 = 0
- 7.8136	+ 17.3256	+ 12.8538	+ 12.8538			- 0.726 = 0
-11.0580	- 10.5983	+ 1696.5453	+ 21.7874	- 18.7978		+ 0.178 = 0
+ 1.8353	+ 12.8538	- 572.7811	+ 11.0185			- 0.313 = 0
- 4.2441		+ 853.8994	- 24.7193	- 12.3101	+ 16.0699	+ 0.071 = 0
			+ 13.1744	- 2.6763	- 28.9190	0.349 = 0
- 4.2441		+ 853.8994	+ 14.1950	+ 17.6207	- 43.2878	+ 0.779 = 0
	+ 5.4118	- 1696.5453	- 21.7874	+ 1.3524	+ 19.6853	- 2.603 = 0
			+ 2.1969	- 0.6546	- 2.6763	+ 0.254 = 0
+92.2459	- 19.6370	- 1136.9650	- 57.0211		+ 13.5481	+ 1.046 = 0
	+378.5667	- 2279.3390	+ 93.2905	+ 26.6309		- 2.809 = 0
		+1946641.9064	+13512.2160	- 8348.5296	-2725.8177	+198.013 = 0
			+ 719.5657	+ 0.9067	- 308.5131	- 5.817 = 0
				+ 464.2463	- 109.5101	- 3.964 = 0
					+ 401.3992	- 1.205 = 0

devised by him, Mr. A. Ziwet assisting in the solution.

Resulting values of  $v$ .

$v_1 = +.0206$	$v_{12} = -.0776$	$v_{23} = -.1018$
$v_2 = -.2199$	$v_{13} = +.4884$	$v_{24} = +.3187$
$v_3 = -.0639$	$v_{14} = +.1411$	$v_{25} = +.0861$
$v_4 = +.2316$	$v_{15} = -.0798$	$v_{26} = +.5236$
$v_5 = -.1598$	$v_{16} = +.0911$	$v_{27} = +.0083$
$v_6 = -.0822$	$v_{17} = -.0773$	$v_{28} = -.6213$
$v_7 = +.0604$	$v_{18} = -.1368$	$v_{29} = +.1832$
$v_8 = +.1878$	$v_{19} = +.0615$	$v_{30} = +.3034$
$v_9 = -.2588$	$v_{20} = +.1210$	$v_{31} = +.0535$
$v_{10} = +.1106$	$v_{21} = -.0471$	$v_{32} = +.0484$
$v_{11} = -.3468$	$v_{22} = -.6446$	$v_{33} = -.3801$
		$v_{34} = +.2768$

We have for check  $[p.vv] = 0.6245$  and  $-[wU] = 0.6249$ , which shows a satisfactory accord. The mean error of an observed direction of unit weight equals

$$\sqrt{\frac{.6247}{17}} = \pm 0''.192$$

and since the average reciprocal of weight equals 3.51, the average weight of a direction is 0.285; hence the *mean error* (after figure-adjustment) of an observed *direction* of average weight\*

$$m = \frac{m_1}{\sqrt{P_0}} = \frac{0.192}{\sqrt{.285}} = \pm 0''.359$$

also the corresponding mean error of an observed *angle* of average weight  $= 0.359 \sqrt{2} = \pm 0''.508$

We have further the *probable error* (after adjustment) of an observed *direction* of average weight,†  $r = 0.6745 m = \pm 0''.242$ , also the corresponding *probable error* of an observed *angle* of average weight  $= .242 \sqrt{2} = \pm 0''.343$

The mean error  $m$  of an adjusted angle is a quantity which has been advantageously used to serve as a practical basis of comparison of the accuracy of triangulations, and may be taken as a convenient average measure for that purpose. In magnitude it does not exceed 1'' for the best work executed, and that limit may be taken to separate the best from moderately good work. In the following table those values of  $m$ , not our own, were taken from Jordan's work (*Vermessungskunde*), Vol. II, § 50.

Davidson, Coast and Geodetic Survey, Yolo base-net, California, 1876-'84	$m = \pm 0''.51$
Gauss, Survey in Hanover	0.59
v. Morozowicz, Survey of Prussia since 1867	0.62
Andrae, Survey of Denmark	0.71
Bessel and Bayer, Survey in East Prussia, 1838	0.72
Boutelle, Coast and Geodetic Survey, New York State, 1880-'83	0.99

As a work of secondary accuracy we may mention here the so-called "horseshoe" triangulation of Eastern Pennsylvania by the Coast and Geodetic Survey, 1875 to 1882, for which  $m = \pm 1''.75$  For the British Ordnance Survey,  $m = \pm 2''.21$

*Determination of the probable error of the adjusted length of the primary side, Mount Helena to Mount Diablo.*

From the relation, side Mount Helena to Mount Diablo =

$$\text{Yolo base} \times \frac{\sin(2-1) \sin(7-5) \sin(13-11)}{\sin(10-9) \sin(26-24) \sin(29-28)}$$

we have:

$$F = \log \sin(2-1) + \log \sin(7-5) + \log \sin(13-11) - \log \sin(10-9) - \log \sin(26-24) - \log \sin(29-28)$$

$$f_i = \frac{\delta F}{dx_i} = \frac{M}{\rho} \cot x_i = M \sin 1'' \cot x_i$$

which may be taken from logarithmic tables (in units of the 6th place of decimals). The values of  $f_i$  are as follows:

$f_1 = -1.9043$	$f_{11} = +2.4854$
$f_2 = +1.9043$	$f_{13} = -2.4854$
$f_5 = -1.9400$	$f_{24} = +4.9427$
$f_7 = +1.9400$	$f_{26} = -4.9427$
$f_9 = +4.4428$	$f_{28} = +5.8045$
$f_{10} = -4.4428$	$f_{29} = -5.8045$

\* This may be roughly compared with the expression  $\sqrt{\frac{[vv]}{n}} = \sqrt{\frac{2.249}{17}} = \pm 0''.364$ , which is practically the same as the above value of  $m$ .

† The *probable error* of an average direction may be roughly compared with the value derived from the closing errors of the 19 triangles, which we have found to be  $\pm 0''.245$ , and which compares well with the above value,  $r = \pm 0''.242$

It will not be required to write out in full the transfer equations; it suffices to substitute in the normal equations  $R_i$  for  $C_i$  and to replace the absolute numbers in the last vertical column by the following numbers:

$[u. af] = + 5.820$	$[u. if] = + 33.773$
$[u. bf] = - 21.155$	$[u. jf] = - 42.290$
etc. = - 23.975	etc. = + 18.574
= - 7.034	= - 19.750
= - 18.698	= - 89.258
= - 12.855	= - 8516.995
= 0	= - 239.169
= 0	= + 303.008
	= - 114.263

The solution\* of the transfer equations gave the values of  $R_i$

$R_1 = - .611$	$R_9 = + .666$
$R_2 = + .352$	$R_{10} = + 2.5$
$R_3 = + 2.43$	$R_{11} = - .215$
$R_4 = + .096$	$R_{12} = + 1.34$
$R_5 = + .57$	$R_{13} = + .122$
$R_6 = - .258$	$R_{14} = + .000\ 507$
$R_7 = + .273$	$R_{15} = + .675$
$R_8 = + .246$	$R_{16} = - .52$
	$R_{17} = + .565$

The above values left reasonably small residuals. The values of  $F_i = f_i + a_i R_1 + b_i R_2 + c_i R_3$  + . . . . . were next found; they are:

$F_1 = - 0.224$	$F_{18} = - 0.128$
$F_2 = - 0.570$	$F_{19} = + 0.306$
$F_3 = - 0.162$	$F_{20} = + 0.544$
$F_4 = + 0.956$	$F_{21} = + 0.333$
$F_5 = - 1.019$	$F_{22} = + 0.240$
$F_6 = - 0.972$	$F_{23} = + 0.482$
$F_7 = + 0.725$	$F_{24} = + 0.410$
$F_8 = + 1.266$	$F_{25} = - 0.302$
$F_9 = + 1.443$	$F_{26} = - 1.163$
$F_{10} = - 1.661$	$F_{27} = + 0.899$
$F_{11} = + 0.555$	$F_{28} = - 0.930$
$F_{12} = - 0.273$	$F_{29} = - 0.070$
$F_{13} = - 0.651$	$F_{30} = + 0.101$
$F_{14} = + 0.587$	$F_{31} = + 0.068$
$F_{15} = + 1.246$	$F_{32} = + 0.670$
$F_{16} = - 1.874$	$F_{33} = - 0.772$
$F_{17} = - 0.095$	$F_{34} = + 0.035$

We next form the values  $u F_i F_i$  and find  $[u. FF] = 74.469$  which is the reciprocal of the weight, or  $\frac{1}{P}$

The mean error of the function or  $m_F = \frac{m_1}{\sqrt{P}} = m_1 \sqrt{[u. FF]} = 0.192 \sqrt{74.469} = \pm 1.654$  expressed in units of the sixth place of decimals of the logarithm of the side. The *probable* error is consequently

$$r_F = 0.6745 m_F = \pm 1.116$$

\*The solution was effected by Mr. Doolittle; part of the former solution of the normal equations came again into use.



From the triangle-side computation we have:

Log distance Mount Helena to Mount Diablo 5.032 332 465  
 $\pm$  1 116

Also distance Mount Helena to Mount Diablo 107728<sup>m</sup>.959  
 $\pm$  0.277

To the above uncertainty is yet to be added the probable error arising from that of the measure\* of the base line itself; the latter value was  $\pm 0^m.00957$ , hence the corresponding probable error of primary side Mount Helena to Mount Diablo :

$$0.00957 \frac{\text{Primary side}}{\text{base}} = 0.00957 \frac{107729.0}{17486.5} = \pm 0^m.0589$$

hence total probable error

$$= \sqrt{(.059)^2 + (.277)^2} = \pm 0^m.283$$

and the same when expressed in units of the sixth place of logarithms =  $\pm 1.141$  It also corresponds to  $\frac{1}{380\ 700}$  part of the length, which for our line is 66.94 statute miles, or 107.73 kilometres, and equals a probable error of  $\pm 0.17$  inch per statute mile, or  $\pm 2^m.63$  per kilometre.

*Triangle-side computation.*

This part of the reduction requires no further explanation. The results are as follows :

	Stations.	Observed angles.	Corrections.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		° ' "	"	"	"		
1.	Yolo, Northwest Base to Southeast Base.					$\pm 0.010$ 17486.512	$\pm 24$ 4. 2427 0319
	Vaca.	25 21 21.287	+0.369	21.656	0.424	21.232	0.3683 1309
	Northwest Base.	47 20 34.196	+0.220	34.416	0.424	33.992	9.8665 3585
	Southeast Base.	107 18 04.749	+0.452	05.201	0.425	04.776	9.9798 9145
					1.273		
	Vaca to Southeast Base.					30029.78	4.4775 5213
	Vaca to Northwest Base.					38985.91	4.5909 0773
	Yolo, Northwest Base to Southeast Base.						4. 2427 0319
	Monticello.	27 12 15.561	+0.171	15.732	0.416	15.316	0.3399 2801
	Northwest Base.	103 42 21.392	+0.348	21.740	0.415	21.325	9.9874 5381
2.	Southeast Base.	49 05 23.480	+0.295	23.775	0.416	23.359	9.8783 7077
					1.247		
	Monticello to Southeast Base.					37160.80	4.5700 8501
	Monticello to Northwest Base.					28906.93	4.4610 0197
	Monticello to Southeast Base.						4.5700 8501
	Vaca.	71 41 15.803	—0.031	15.772	0.802	14.970	0.0225 7048
	Monticello.	50 06 05.379	—0.168	05.211	0.803	04.408	9.8848 9663
	Southeast Base.	58 12 41.269	+0.156	41.425	0.803	40.622	9.9294 1712
					2.408		
	Vaca to Southeast Base.					30029.78	4.4775 5212
3.	Vaca to Monticello.					33271.52	4.5220 7261

\*Coast and Geodetic Survey Report for 1883, Appendix No. 11.

*Triangle-side computation—Continued.*

	Stations.	Observed angles.	Corrections.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		° ' "	"	"	"		
4.	Northwest Base to Vaca.						4. 5909 0773
	Monticello.	77 18 20. 940	+0. 003	20. 943	0. 794	20. 149	0. 0107 4779
	Northwest Base.	56 21 47. 196	+0. 127	47. 323	0. 794	46. 529	9. 9204 1709
	Vaca.	46 19 54. 516	—0. 400	54. 116	0. 794	53. 322	9. 8593 4645
					2. 382		
	Monticello to Vaca.					33271. 52	4. 5220 7261
	Monticello to Northwest Base.					28906. 93	4. 4610 0197
5.	Northwest Base to Southeast Base.						4. 2427 0319
	Mount Diablo.	4 45 11. 792	+0. 437	12. 229	0. 450	11. 779	1. 0816 2825
	Northwest Base.	20 04 24. 632	+0. 078	24. 710	0. 450	24. 260	9. 5355 7735
	Southeast Base.	155 10 24. 200	+0. 211	24. 411	0. 450	23. 961	9. 6231 1971
					1. 350		
	Mount Diablo to Southeast Base.					72428. 38	4. 8599 0879
	Mount Diablo to Northwest Base.					88603. 56	4. 9474 5115
6.	Vaca to Northwest Base.						4. 5909 0773
	Mount Diablo.	18 19 09. 648	—0. 233	09. 415	1. 339	08. 076	0. 5026 4762
	Vaca.	134 24 44. 984	—0. 088	44. 896	1. 340	43. 556	9. 8538 9580
	Northwest Base.	27 16 09. 564	+0. 143	09. 707	1. 339	08. 368	8. 6610 2528
					4. 018		
	Mount Diablo to Northwest Base.					88603. 56	4. 9474 5115
	Mount Diablo to Vaca.					56830. 39	4. 7545 8063
7.	Vaca to Southeast Base.						4. 4775 5212
	Mount Diablo.	23 04 21. 440	+0. 205	21. 645	1. 365	20. 280	0. 4068 3319
	Vaca.	109 03 23. 697	—0. 457	23. 240	1. 365	21. 875	9. 9755 2348
	Southeast Base.	47 52 19. 451	—0. 241	19. 210	1. 365	17. 845	9. 8701 9532
					4. 095		
	Mount Diablo to Southeast Base.					72428. 38	4. 8599 0879
	Mount Diablo to Vaca.					56830. 39	4. 7545 8063
8.	Monticello to Northwest Base.						4. 4610 0197
	Mount Diablo.	18 35 38. 518	+0. 188	38. 706	2. 154	36. 552	0. 4964 1144
	Monticello.	77 46 30. 784	—0. 057	30. 727	2. 154	28. 573	9. 9900 3773
	Northwest Base.	83 37 56. 760	+0. 270	57. 030	2. 155	54. 875	9. 9973 1204
					6. 463		
	Mount Diablo to Northwest Base.					88603. 56	4. 9474 5114
	Mount Diablo to Monticello.					90100. 14	4. 9547 2545
9.	Monticello to Southeast Base.						4. 5700 8501
	Mount Diablo.	23 20 50. 310	+0. 625	50. 935	2. 189	48. 746	0. 4019 7948
	Monticello.	50 34 15. 223	—0. 228	14. 995	2. 189	12. 806	9. 8878 4429
	Southeast Base.	106 04 60. 720	—0. 084	60. 636	2. 188	58. 448	9. 9826 6096
					6. 566		
	Mount Diablo to Southeast Base.					72428. 38	4. 8599 0878
	Mount Diablo to Monticello.					90100. 14	4. 9547 2545

*Triangle-side computation—Continued.*

	Stations.	Observed angles.	Corrections.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		° ' "	"	"	"		
10*	Monticello to Vaca.						4. 5220 7261
	Mount Diablo.	0 16 28. 870	+0. 4200	29. 2900	0. 021	29. 2690	2. 3191 1240
	Monticello.	0 28 09. 844	—0. 0607	09. 7833	0. 021	09. 7623	7. 9133 9562
	Vaca.	179 15 20. 500	+0. 4887	20. 9887	0. 020	20. 9687	8. 1135 4044
					0. 062		
	Mount Diablo to Vaca.					56830. 39	4. 7545 8063
	Mount Diablo to Monticello.					90100. 14	4. 9547 2545
11.	Monticello to Vaca.						4. 5220 7261
	Mount Helena.	33 17 28. 028	—0. 630	27. 398	1. 038	26. 360	0. 2605 1745
	Monticello.	107 11 02. 769	+0. 198	02. 967	1. 037	01. 930	9. 9801 6777
	Vaca.	39 31 33. 095	—0. 347	32. 748	1. 038	31. 710	9. 8037 4467
					3. 113		
	Mount Helena to Vaca.					57910. 57	4. 7627 5783
	Mount Helena to Monticello.					38577. 56	4. 5863 3473
12.	Mount Helena to Vaca.						4. 7627 5783
	Mount Diablo.	20 19 59. 563	+0. 963	60. 526	1. 800	58. 726	0. 4590 7588
	Mount Helena.	19 56 15. 830	+0. 805	16. 635	1. 800	14. 835	9. 5327 4692
	Vaca.	139 43 47. 405	+0. 835	48. 240	1. 801	46. 439	9. 8104 9875
					5. 401		
	Mount Diablo to Vaca.					56830. 39	4. 7545 8063
	Mount Diablo to Mount Helena.					107728. 96	5. 0323 3246
13.	Mount Helena to Monticello.						4. 5863 3473
	Mount Diablo.	20 03 30. 693	+0. 543	31. 236	2. 817	28. 419	0. 4647 4453
	Mount Helena.	53 13 43. 858	+0. 175	44. 033	2. 817	41. 216	9. 9036 4619
	Monticello.	106 42 52. 925	+0. 258	53. 183	2. 818	50. 365	9. 9812 5320
					8. 452		
	Mount Diablo to Monticello.					90100. 14	4. 9547 2545
	Mount Diablo to Mount Helena.					107728. 96	5. 0323 3246
14.	Monticello to Vaca.						4. 5220 7261
	Mount Tamalpais.	18 23 19. 328	—0. 429	18. 899	1. 607	17. 292	0. 5010 6594
	Monticello.	39 38 43. 916	+0. 139	44. 055	1. 607	42. 448	9. 8048 4153
	Vaca.	121 58 01. 649	+0. 219	01. 868	1. 608	00. 260	9. 9285 7792
					4. 822		
	Mount Tamalpais to Vaca.					67294. 58	4. 8279 8008
	Mount Tamalpais to Monticello.					89478. 04	4. 9517 1647
15.	Mount Helena to Monticello.						4. 5863 3473
	Mount Tamalpais.	25 30 07. 828	—0. 005	07. 823	2. 699	05. 124	0. 3659 9303
	Mount Helena.	86 57 41. 069	+0. 295	41. 364	2. 700	38. 664	9. 9993 8871
	Monticello.	67 32 18. 853	+0. 059	18. 912	2. 700	16. 212	9. 9657 3403
					8. 099		
	Mount Tamalpais to Monticello.					89478. 04	4. 9517 1647
	Mount Tamalpais to Mount Helena.					82806. 00	4. 9180 6179

\* This triangle is of no practical value.

*Triangle-side computation—Continued.*

	Stations.	Observed angles.	Corrections.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		° ' "	"	"	"		
16.	Mount Helena to Vaca.						4. 7627 5783
	Mount Tamalpais.	43 53 27. 156	—0. 434	26. 722	3. 269	23. 453	0. 1590 9500
	Mount Helena.	53 40 13. 041	+0. 925	13. 966	3. 269	10. 697	9. 9061 2725
	Vaca.	82 26 28. 554	+0. 566	29. 120	3. 270	25. 850	9. 9962 0897
					9. 808		
	Mount Tamalpais to Vaca.					67294. 58	4. 8279 8008
	Mount Tamalpais to Mount Helena.					82806. 00	4. 9180 6180
17.	Mount Tamalpais to Mount Helena.						4. 9180 6179
	Mount Diablo.	49 47 50. 700	—0. 597	50. 103	4. 192	45. 911	0. 1170 4767
	Mount Tamalpais.	96 28 24. 920	+0. 223	25. 143	4. 193	20. 950	9. 9972 2300
	Mount Helena.	33 43 57. 211	+0. 120	57. 331	4. 192	53. 139	9. 7445 2821
					12. 577		
	Mount Diablo to Mount Helena.					107728. 96	5. 0323 3246
	Mount Diablo to Mount Tamalpais.					60205. 71	4. 7796 3767
18.	Mount Tamalpais to Monticello.						4. 9517 1647
	Mount Diablo.	69 51 21. 393	—0. 054	21. 339	4. 310	17. 029	0. 0274 1654
	Mount Tamalpais.	70 58 17. 092	+0. 229	17. 321	4. 310	13. 011	9. 9755 9243
	Monticello.	39 10 34. 072	+0. 198	34. 270	4. 310	29. 960	9. 8005 0466
					12. 930		
	Mount Diablo to Monticello.					90100. 14	4. 9547 2544
	Mount Diablo to Mount Tamalpais.					60205. 71	4. 7796 3767
19.	Mount Tamalpais to Vaca.						4. 8279 8008
	Mount Diablo.	70 07 50. 263	+0. 366	50. 629	2. 724	47. 905	0. 0266 5687
	Mount Tamalpais.	52 34 57. 764	+0. 657	58. 421	2. 723	55. 698	9. 8999 4368
	Vaca.	57 17 18. 851	+0. 269	19. 120	2. 723	16. 397	9. 9250 0073
					8. 170		
	Mount Diablo to Vaca.					56830. 39	4. 7545 8063
	Mount Diablo to Mount Tamalpais.					60205. 71	4. 7796 3768

The following four triangles (approximately adjusted) are given here with reference to remarks on standard latitude and azimuth, further on:

	Stations.	Observed angles.	Corrections.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		° ' "	"	"	"		
20.	Mount Diablo to Mount Helena.						5. 0323 3246
	Mount Lola.	28 48 68. 349	—0. 030	68. 319	19. 080	49. 239	0. 3169 865
	Mount Diablo.	73 06 32. 761	—0. 326	32. 435	19. 080	13. 355	9. 9808 358
	Mount Helena.	78 04 76. 664	—0. 177	76. 487	19. 081	57. 406	9. 9905 370
					57. 241		
	Mount Lola to Mount Helena.					213872. 4	5. 3301 548
	Mount Lola to Mount Diablo.					218703. 6	5. 3398 560

*Triangle-side computation—Completed.*

	Stations.	Observed angles.	Corrections.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		° ' "	"	"	"		
21.	Mount Diablo to Mount Helena.						5. 0323 3246
	Round Top.	27 47 26.404	+0.504	26.908	17.045	09.863	0. 3314 541
	Mount Diablo.	97 31 65.474	—0.457	65.017	17.045	47.972	9. 9962 386
	Mount Helena.	54 41 18.960	+0.250	19.210	17.045	02.165	9. 9116 771
					51.135		
	Round Top to Mount Helena.					229100.1	5. 3600 252
22.	Round Top to Mount Diablo.					188566.1	5. 2754 637
	Mount Diablo to Mount Lola.						5. 3398 560
	Round Top.	96 40 15.474	+0.026	15.500	14.431	01.069	0. 0029 468
	Mount Diablo.	24 25 32.713	—0.131	32.582	14.431	18.151	9. 6164 224
	Mount Lola.	58 54 55.366	—0.155	55.211	14.431	40.780	9. 9326 610
					43.293		
23.	Round Top to Mount Lola.					91038.5	4. 9592 252
	Round Top to Mount Diablo.					188566.2	5. 2754 638
	Round Top to Mount Helena.						5. 3600 252
	Mount Lola.	87 43 63.715	—0.184	63.531	16.466	47.065	0. 0003 410
	Round Top.	68 52 49.070	—0.478	48.592	16.467	32.125	9. 9697 886
	Mount Helena.	23 23 57.704	—0.427	57.277	16.467	40.810	9. 5988 589
					49.400		
	Mount Lola to Mount Helena.					213872.4	5. 3301 548
	Mount Lola to Round Top.					91038.5	4. 9592 251

The sides as here computed may advantageously be regarded as lines of alignment. These lines have the property that for every point in the line the vertical plane at that point passes, when produced, through the terminal points, or, in other words, the azimuthal difference, at any point, of the initial and terminal points is  $180^\circ$ . This line has, therefore, an advantage over the geodetic line, inasmuch as the first and last linear elements coincide in direction with the respective normal plane sections at the terminal points; hence the line of alignment enters directly into the *measures* of horizontal directions, whereas the geodetic line deviates abruptly from the normal section, generally by one-third of the angle\* contained between the two plane sections, one vertical at the first station and passing through the opposite one, the other vertical at the opposite station and passing through the first.

*Formulae for the computation of geodetic latitudes, longitudes, and azimuths sufficiently precise for sides of the largest triangles that may be directly measured.*

In Appendix No. 7, Coast and Geodetic Survey Report for 1884, are contained the formulæ and tables ordinarily employed in the Survey for the computation of geographical positions and their mutual azimuths. In the application of these formulæ seven-place logarithms are used, and the results obtained possess all needful precision, provided the length of side or distance between two

\* The geodetic line supposed drawn between Lake Tahoe and the Colorado River station and forming part of the boundary between California and Nevada, is 404.7 statute miles, or 651.2 kilometres in length; for this line we have calculated the angle at the southern end between the plane vertical section and the initial element of the curve to be  $0''.82$  and the corresponding angle at the northern end to be  $0''.73$ , the angular difference between the two sections being three times these amounts, respectively. Near the middle of the line these two plane sections pass each other at a distance of  $1^m.829$ , or very nearly 6 feet.

points does not much exceed  $1^\circ$ , or, roughly, 69 statute miles or 111 kilometres, and the formulæ may even be used up to 100 statute miles when moderate accuracy suffices. The primary triangulations of California, Nevada, and Utah are on so large a scale that a stricter expression for the numerical computation is demanded. Among the different solutions of the problem we prefer the one given by Lieutenant-Colonel Clarke,\* which was employed in the computation of the larger triangles of the Ordnance Survey of Great Britain, and also in the computation of the verification and extension of the arc of the meridian at the Cape of Good Hope. The method is found convenient even without specially prepared tables, such as accompany the Coast and Geodetic Survey formulæ, two of which tables, however, could be utilized if extended to 8 or 9 places of decimals; this number of decimals is demanded by the extended formulæ for the numerical logarithmic work. The surface of development is the spheroid, the dimensions of which were published by Clarke in 1866, and which was found to be more nearly conformable to the earth's figure (and to the surface of the United States in particular) than the Besselian spheroid previously employed.

Let  $\varphi, \lambda$  be the latitude and longitude of the given point,  $\alpha$  the azimuth and  $s$  the distance to the second point, then the latitude  $\varphi'$ , the longitude  $\lambda'$  and the reverse azimuth  $\alpha'$  may be computed by the following formulæ:

$$\begin{aligned}\theta &= \frac{s}{r \sin 1''} + \frac{e^2 \theta^2 \sin^2 1''}{6(1-e^2)} \cos^2 \varphi \cos^2 \alpha \\ \zeta &= \frac{e^2 \theta^2 \sin 1''}{4(1-e^2)} \cos^2 \varphi \sin 2\alpha \\ \tan \frac{1}{2}(\alpha' + \zeta - \Delta \lambda) &= \frac{\sin \frac{1}{2}(\gamma - \theta)}{\sin \frac{1}{2}(\gamma + \theta)} \cot \frac{\alpha}{2} \\ \tan \frac{1}{2}(\alpha' + \zeta + \Delta \lambda) &= \frac{\cos \frac{1}{2}(\gamma - \theta)}{\cos \frac{1}{2}(\gamma + \theta)} \cot \frac{\alpha}{2} \\ \varphi' - \varphi &= \frac{s}{\rho \sin 1''} \cdot \frac{\sin \frac{1}{2}(\alpha' + \zeta - \alpha)}{\sin \frac{1}{2}(\alpha' + \zeta + \alpha)} \left[ 1 + \frac{\theta^2 \sin^2 1''}{12} \cos^2 \frac{1}{2}(\alpha' - \alpha) \right]\end{aligned}$$

The distance  $s$  is the length of either of the *elliptic arcs* from the first to the second, or from the second to the first point, and differs only infinitesimally from a *line of alignment* and from a *geodetic line* between the same points.  $r$  is the normal, extended to the minor axis, for the given point or latitude, or

$$r = \frac{a}{(1 - e^2 \sin^2 \varphi)^{\frac{1}{2}}}$$

and  $\rho$  is the radius of curvature of the meridian for the middle latitude  $\frac{1}{2}(\varphi + \varphi')$  or

$$\rho = \frac{a(1-e^2)}{(1 - e^2 \sin^2 \varphi)^{\frac{3}{2}}}$$

(see our factors A and B, report of 1884).  $\theta$  is the angle subtended at the foot of the normal or axis by the curve  $s$  and it suffices for most distances, unless extremely great, to put

$$\theta = \frac{s}{r \sin 1''}$$

the second term in the expression of  $\theta$  being very small. The angle  $\zeta$ , also, is always a small quantity. We put  $\gamma = 90^\circ - \varphi$ , the colatitude, and  $\Delta \lambda = \lambda' - \lambda$ , the difference of longitude. The azimuthal angles  $\alpha$  and  $\alpha' + \zeta$  are those within the polar triangle the solution of which is contained in the third and fourth of the given expressions and these angles are readily changed to conform to the azimuths of the line as usually reckoned in the direction from the south meridian westward to  $360^\circ$ . If  $s_0$  be the length of an arc whose amplitude is  $\mu$  and whose radius of curvature for the

\* See his work on Geodesy, Oxford, 1880, but in particular the Ordnance Survey of Great Britain, London, 1858.

middle point (mean between the terminal points) is  $\rho_0$  then with greater precision than in the above formulæ

$$\mu = \frac{s_0}{\rho_0} - \left(\frac{\mu}{2}\right)^2 e^2 \cos 2\varphi$$

but this term in  $e^2$  will seldom come into use. Using 8 places in the logarithms,  $\Delta \varphi$  and  $\Delta \lambda$  may be stated to 3 places of decimals in the seconds, with 9 place logarithms one place further may be had.

For convenience of reference we add the following constants and their logarithms:

$a = 6378206^m.4$	[6.80469857]	$a : b = 294.98 : 293.98$
$b = 6356583^m.8$	[6.80322378]	
$e^2 = \frac{a^2 - b^2}{a^2} = 0.0067686580$	[7.83050257]	
$1 - e^2$	[9.99705042]	
$a(1 - e^2)$	[6.80174898]	
$\frac{e^2 \sin^2 1''}{6(1 - e^2)}$	[6.42645]	
$\frac{e^2 \sin 1''}{4(1 - e^2)}$	[1.91697]	
$\frac{\sin^2 1''}{12}$	[8.29197]	
$\sin 1''$	[4.68557487]	

For the longest line in the Yolo base-figure, Mount Helena to Mount Diablo, the difference in the results by the two methods, and when 8 place logarithms are employed in the computation is just appreciable, viz, in latitude  $0''.001$ , in longitude  $0''.003$ , and in azimuth  $0''.002$

There remains the computation of the geographical position of each point; for this purpose we need a standard geodetic latitude  $\varphi_0$ , a standard geodetic azimuth  $\alpha_0$ , and the introduction of the telegraphic longitude  $\lambda$ , there being but one station.

*Determination of standard geodetic data for the computation of geographical positions.*

Including the stations Mount Lola and Round Top, which are the easternmost points of the Davidson quadrilaterals, we have nine stations, at each of which the latitude and azimuth were determined astronomically, and we shall take the mean results derived from all of these observations for the formation of the standard values  $\varphi_0$  and  $\alpha_0$ .

The direct results of the astronomical observations for latitude require two corrections—one the reduction to the station point  $\Delta$ , the other the correction for curvature of the vertical or the reduction to the sea-level. The heights required for the latter purpose are given in Appendix No. 10, Coast and Geodetic Survey Report for 1884 (Mount Lola being 2796.4 m, or 9175 feet, and Round Top 3173.5 m., or 10412 feet high). For the expression of the curvature between the sea level and the altitude of the station we have (see Clarke's Geodesy, pp. 101-102)

$$\delta\varphi = -\frac{h}{r \sin 1''} \left( \frac{5}{2} m - e' \right) \sin 2\varphi$$

Putting

$$\frac{5}{2} m - e' = 0.0052^* \quad \text{and} \quad \log(r \sin 1'') = 1.490$$

then for  $h$  the height in metres, and  $\delta\varphi$  the correction in seconds, we have for the latitude  $\varphi$

$$\delta\varphi = -.000167 h \sin 2\varphi \quad \text{or} \quad [6.212] h$$

for the average latitude  $39^\circ$ , the number within brackets being a logarithm.

\*G. Zachariae, in his *Principal Geodetic Points* (German translation by Dr. Lampe, Berlin, 1878), prefers the value 0.00513

*Geodetic or standard latitude,  $\varphi_0$  of Mount Helena, for the Davidson quadrilaterals.*

No.	Astronomical station.	Year of observation.	Observed astronomical latitude.	Probable error.	Reduction to $\Delta$ 'n station.	Reduction to sea-level.	Resulting seconds of latitude. A.	Adopted geodetic latitude. G.	A — G.
			° / "	"	"	"	"	° / "	"
1	Southeast Yolo Base.	1880	38 31 34.52	$\pm 0.06$	-0.45	-0.00	34.07	38 31 35.41	-1.34
2	Northwest Yolo Base.	1880	38 40 37.34	$\pm 0.07$	-0.13	-0.01	37.20	38 40 38.03	-0.83
3	Monticello.	1880	38 39 46.51	$\pm 0.09$	-0.31	-0.15	46.05	38 39 43.85	+2.20
4	Vaca.	1880	38 22 23.38	$\pm 0.06$	+0.37	-0.12	23.63	38 22 27.02	-3.39
5	Mount Diablo.	1876	37 52 49.59	$\pm 0.06$	0.00	-0.19	49.40	37 52 48.70	+0.70
6	Mount Tamalpais.	1882	37 55 19.04	$\pm 0.08$	-0.04	-0.13	18.87	37 55 20.69	-1.82
7	Mount Helena.	1876	38 40 01.02	$\pm 0.06$	+0.47	-0.22	01.27	38 40 04.26	-2.99
8	Mount Lola.	1879	39 25 57.98	$\pm 0.06$	-0.22	-0.46	57.30	39 25 53.34	+3.96
9	Round Top.	1879	38 39 46.89	$\pm 0.08$	+0.01	-0.52	46.38	38 39 43.64	+2.74
								Mean.	-0.09

The mean difference A — G is small, approximating to zero, as it should do. We therefore retained and adopted for the present  $\varphi_0$  for Mount Helena,  $38^\circ 40' 04''.26$ , with a probable uncertainty of  $\pm 0''.59$ . The average local deflection in the meridian is about  $2''.2$

*Geodetic or standard azimuth,  $\alpha_0$  of direction Mount Helena to Mount Diablo, for the Davidson quadrilaterals.*

No.	Station occupied.	To station observed.	Observed astronomical azimuth.	Probable error.	Reduction to sea-level.	Resulting seconds of azimuth. A'.	Adopted geodetic azimuth. G'.	A' — G'.
			° / "	"	"	"	° / "	"
1	Southeast Yolo Base.	Northwest Yolo Base.	163 07 13.51	$\pm 0.18$	-0.00	13.51	163 07 15.07	-1.56
2	Northwest Yolo Base.	Southeast Yolo Base.	343 05 02.35	$\pm 0.16$	-0.00	02.35	343 05 04.03	-1.68
3	Monticello.	Mount Helena.	91 04 25.16	$\pm 0.21$	-0.00	25.16	91 04 23.79	+1.37
4	Vaca.	Southeast Yolo Base.	235 38 36.44	$\pm 0.28$	+0.00	36.44	235 38 33.47	+2.97
5	Mount Diablo.	Mount Helena.	144 28 16.13	$\pm 0.15$	---	16.13	144 28 15.06	+1.07
6	Mount Tamalpais.	Mount Diablo.	274 15 15.39	$\pm 0.14$	-0.01	15.38	274 15 15.71	-0.33
7	Mount Helena.	Mount Diablo.	324 01 24.86	$\pm 0.19$	---	24.86	324 01 31.04	-6.18
8	Mount Lola.	Mount Helena.	67 21 62.57	$\pm 0.17$	-0.16	62.41	67 21 59.55	+2.86
9	Round Top.	Mount Helena.	90 58 53.67	$\pm 0.13$	-0.16	53.51	90 58 53.01	+0.50
							Mean.	-0.11



The mean difference is sufficiently near to 0 to make it desirable to retain for the present the old value, and we adopt for the present  $\alpha_0$ , Mount Helena to Mount Diablo,  $324^\circ 01' 31''.04 \pm 0''.64$

This value will slightly change after Mount Lola and Round Top shall have been finally adjusted. The average local difference in azimuth is about  $2''.1$

At the stations Mount Diablo and Mount Helena the astronomical azimuths were referred to a mark, and not to a triangulation point, and the same is the case at Mount Lola and Round Top. The reference to these stations in the preceding table would therefore be in a measure arbitrary, since the value must depend on the adjustment of the directions of the figure, but by applying a correction which is the mean of all corrections to the lines at the station the reference of the astronomical meridian to the geometrical figure of the triangulation is effected with respect to all the directions; thus, for the two stations in question:

At Mount Diablo:

Observed azimuth of mark (Clayton), $9^\circ 42' 25''.92$ W. of N. $\pm 0''.10$ ;	
hence astronomical azimuth of mark .....	170 17 34.08
and, when reduced to the sea-level .....	170 17 34.07

At Mount Diablo the mean correction to the 6 adjusted directions is  $+''023(\pm .11)$ ;

this, added to the observed geodetic direction of the azimuth mark ( $25^\circ 49' 17''.194$ ), gives (see table below) .....

Hence, with the corrected direction to Mount Helena (see below) ... 25 49 17.217

the angle between the mark and Mount Helena, adjusted .....

And the astronomical azimuth referred to Mount Helena becomes, as given in the preceding table .....

Similarly at Mount Helena:

Observed azimuth of mark (Woods)  $9^\circ 18' 14''.36$  E. of N.  $\pm 0''.14$  .. 189 18 14.36

Same reduced to sea-level .....

Mean correction to 4 adjusted directions at station —  $''032 (\pm .13)$ :

Angle between the mark and Mount Diablo, adjusted .....

Astronomical azimuth referred to Mount Diablo .....

as given in the preceding table.

We have also the following table of adjusted directions at these two stations:

At Mount Diablo. Directions to—	Result of station adjust- ment.	Corr'n. Figure adjust- ment.	Final seconds.	At Mount Helena. Directions to—	Result of station adjust- ment.	Corr'n. Figure adjust- ment.	Final seconds.
	° / "	"	"		° / "	"	"
Mount Helena.	359 59 59.918	— .645	59 273	Mount Diablo.	359 59 59.927	+ .183	60.110
Monticello.	20 03 30.611	— .102	30.509	Mount Tamalpais.	33 43 57.138	+ .303	57.441
Vaca.	20 19 59.481	+ .319	59.800	Azimuth mark (Woods).	225 16 49.650		(49.618)
Azimuth mark (Clayton).	25 49 17.194		(17.217)	Monticello.	306 46 16.069	+ .008	16.077
Northwest Base.	38 39 09.129	+ .086	09.215	Vaca.	340 03 44.097	— .621	43.476
Southeast Base.	43 24 20.921	+ .524	21.445		Mean.	— .032	
Mount Tamalpais.	310 12 09.218	— .047	09.171				
	Mean.	+ 0.023					

Tables of resulting adjusted directions were prepared for all stations, since the respective mean corrections are to be applied to all other subordinate directions not yet adjusted before they can be submitted to the process of the next figure adjustment, which ordinarily is of a secondary character.

For the standard longitude of the triangulation about the Yolo Base we have to retain, at present, the telegraphic longitude of San Francisco, station at Washington square, viz:  $\lambda = 8^h 09^m 38^s.34$ , see Coast and Geodetic Survey Report for 1884, Appendix No. 11, p. 424, and derive from it for Mount Helena the value  $\lambda_0 = 122^\circ 38' 01''.41$

These geodetic data,  $\varphi_0$ ,  $\alpha_0$ ,  $\lambda_0$ , are subject to changes hereafter, but generally standard data are best retained, and the small corrections noted, so long as the changes do not exceed the respective probable errors of these quantities. The resulting geodetic positions are appended.

The above is respectfully submitted by

CHAS. A. SCHOTT,  
Assistant, in charge Computing Division.

*Geodetic results of the Davidson quadrilaterals, introducing the Yolo Base into the Primary Triangulation of California.*

**VICINITY OF YOLO BASE, CALIFORNIA.**

[Developed on the Clarke spheroid of 1866.]

Stations.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° / "		° / "	
Mount Helena.	38 40 04.260	131.4	122 38 01.410	34.1
Mount Diablo.	37 52 48.700	1501.4	121 54 51.948	1269.7
Vaca.	38 22 27.016	833.0	122 05 05.607	136.1
Monticello.	38 39 43.848	1352.0	122 11 25.961	627.7
Southeast Yolo Base.	38 31 35.408	1091.8	121 48 02.176	52.7
Northwest Yolo Base.	38 40 38.026	1172.5	121 51 32.220	778.9
Mount Tamalpais.	37 55 20.689	637.8	122 35 48.774	1191.3
Round Top.	38 39 43.636	1345.5	120 00 04.997	120.8
Mount Lola.	39 25 53.342	1645.0	120 21 55.496	1327.3

From station.	Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
	° / "	° / "		Metres.	
Mount Diablo.	144 28 15.065	324 01 31.040	Mount Helena.	107728.96	5.0323 3246
Vaca.	124 25 44.948	304 05 14.405	Mount Helena.	57910.57	4.7627 5783
	344 41 56.708	164 48 15.590	Mount Diablo.	56830.39	4.7545 8063
Monticello.	343 53 20.825	163 57 17.696	Vaca.	33271.52	4.5220 7261
	91 04 23.793	270 47 47.007	Mount Helena.	38577.56	4.5863 3473
Southeast Base.	55 49 09.875	235 38 33.468	Vaca.	30029.78	4.4775 5212
	114 01 51.300	293 47 15.614	Monticello.	37160.80	4.5700 8501
Northwest Base.	343 05 04.028	163 07 15.075	Southeast Base.	17486.512	4.2427 0319
	86 47 25.767	266 34 59.882	Monticello.	28906.93	4.4610 0196
Mount Tamalpais.	221 40 17.291	41 59 15.828	Vaca.	67294.58	4.8279 8008
	274 15 15.712	94 40 24.961	Mount Diablo.	60205.71	4.7796 3767
Round Top.	90 58 53.01	269 20 11.83	Mount Helena.	229100.1	5.3600 252
Mount Lola.	339 37 56.02	159 51 41.60	Round Top.	91038.53	4.9592 252



## APPENDIX No. 10.

### ON GEODETIC RECONNAISSANCE.

By CHARLES O. BOUTELLE, Assistant.

The accompanying memoir on Reconnaissance is intended to supply such information as my long experience suggests on a subject not fully treated in any text-book on Geodetic Surveying which has come under my notice.

It is not intended to supersede any portion of Appendix No. 9, Report of 1882, on the field work of the triangulation, but rather to enlarge and illustrate that portion of it which treats of Reconnaissance, by examples drawn from actual cases occurring in the usual routine, and by bringing out very fully the principles, theoretical and practical, which should govern in carrying on this very difficult, responsible, and laborious portion of Coast and Geodetic Survey duty. No department of professional labor calls for the exercise of a higher order of ability, or better repays thorough execution.

#### RECONNAISSANCE.—PRIMARY TRIANGULATION AND BASE LINES.

Primary triangulation over any extended geographical area should be so laid out and conducted that its results should approach as near to absolute precision as the present condition of scientific research, theoretical, instrumental, and practical, will permit. No refinement in observation or reduction should be omitted which it is possible to supply. It should start from a *Base* so selected as to ground as to present the fewest natural obstacles to the passage of apparatus of the most delicate nature over every part of it. The length of this base should not be less than from eight to twelve kilometers, while its direction and terminals should be so selected as to admit of the formation upon it of triangles of gradually increasing sides, as the configuration of the surrounding country may admit.

#### OF BASE LINES.

The terminals of a base line need not of necessity be intervisible from the ground, provided they can be rendered so from elevations of twelve to twenty meters. At no one of the primary bases of the Coast Survey at Bodie's Island, North Carolina, at Edisto Island, South Carolina, at Epping, Me., or at the Atlanta Base, were the termini intervisible from the ground.

While the nearest approach to a level plain is decidedly the most favorable for a base line, it is not an essential.

In the earlier bases measured in the Southern States near the ocean, small grades were always to be had, and the number of level planes largely predominated; but at the Epping Base, in Maine, measured in 1857, gradients of 1 in 20, or of an angular value of  $3^\circ$ , were adopted with entire success. In 1872, when prolonged search in the vicinity of Atlanta, Ga., developed only greatly undulating surfaces, a base-line was finally selected, with gradients as large as  $5^\circ$ , or 1 in 11.5. This base, which was 9.3 kilometers in length, was divided into no less than 270 different planes, ranging in their slopes from level to  $5^\circ$ . It was measured three times, and the apparatus upon the second measure was carried in the opposite direction to that of the first and third, so that ascending slopes upon the first were descending slopes upon the second, yet the accord of the two measures was so nearly perfect as to demonstrate that the apparatus could be well and safely used upon so diversified a surface. With the new primary-base apparatus, used at the Yolo Base, in California, the maximum grade was slightly greater, or  $5^\circ 21'$ . At this base, also, two measurements were made in opposite directions, with the same result.

In both these bases small sharp hollows were crossed upon trestle-work, which in former bases had been considered inadmissible. Embankments of crib-work were also used to advantage at Epping in 1857 and at the Atlanta Base in 1873.

These points will be useful in searching for future base lines, and will enable the observer to pay greater attention to the base connections, both in respect to geometric conditions and to gradual development. Examples of the best forms of such connections may be seen upon sketch No. 3, accompanying the Coast and Geodetic Survey Annual Report for 1884. The first primary base of the survey was measured by Mr. Hassler in 1834, near the sea-beach of Fire Island. It was liable to be destroyed by the encroachment of the sea upon the land, and it was ingeniously transferred from the "Measured Base" to the Interior or "Mountain Base" upon Long Island, extending from "West Hills" to "Ruland" by a quadrilateral of good proportions, whence another quadrilateral, with gradually increasing sides, carries the system across Long Island Sound to another longer side from "Wooster" to Sandford, and furnishes bases for extending the reticulation in both directions along the coast and also into the interior.

Another example of base connection, having every element of geometrical precision which could be asked for, may be seen upon the same sketch, at the Epping Base, in Maine, where the terminals connect with the three subsidiary stations, "Burke," "Pigeon," and "Tunk," and gradually enlarge the sides to the dimensions of the primary triangulation. Still another example of gradual expansion, through quadrilaterals, may be seen upon sketch No. 11, Report for 1884, where the measured "Yolo Base" is carried in two quadrilaterals of good shape from the plain to the mountain summits.

#### RECONNAISSANCE FOR STATIONS OF A PRIMARY TRIANGULATION.

With bases measured and the base-connection established, the next step is a reconnaissance for the extension of the primary triangulation by the selection of the most suitable points in the proposed system of triangles.

Certain general principles must of necessity govern this work, which is one requiring the exercise of skill and good judgment combined with readiness in the application of geometric principles in the most varied forms of practical application to surveys over large areas.

These principles are—

(1) Primary triangulation should be carried on with the fewest possible number of stations which the configuration of the country will allow, and at the same time preserve the highest order of precision. This is best attainable by a system of quadrilaterals with every point intervisible; and next by a system of hexagons or pentagons where each exterior point sees a central interior station but does not necessarily see every other exterior point.

(2) Primary stations should occupy crests of ridges, or the highest accessible summits of mountain ranges. This is especially necessary in the United States, whose population and resources are so rapidly increasing. Although the particular object of the work in hand may be simply to connect certain points more or less distant by a geodetic chain, yet in a few years that very chain may of necessity be enlarged in every direction to meet demands for more precise interior surveys. If the highest summits are chosen at first, even at greater first cost of time, labor, and money, then when the time arrives (as it surely will) for extending surveys in new directions the old bases will be the best possible under all circumstances.

The writer desires to especially impress this point upon future observers, who will be tempted, as he has been (and too often yielded), into selection of some point, not a crest but near one, convenient of access, cleared of forest timber, and filling every condition needed for the work immediately in hand. I cite one case to show how this has cost largely in the end.

In 1845 a primary triangulation was laid out to connect Washington with the Kent Island base, near Annapolis. A point, "Soper" (see sketch 4, Coast Survey Report of 1874), was chosen because it involved lines of least cutting for connection with stations in and near the capital city, and could be occupied, at small cost, without elevation of the 30-inch theodolite which was used at the station.

In 1868 the attempt to carry a chain of primary triangles through the flat and densely wooded

country close upon the seaboard, south of the Chesapeake, was abandoned, and it was decided to continue the chain which then extended from New Brunswick to Virginia, along the first range of hills parallel to the sea-coast, which was the origin of the "Blue Ridge triangulation." It was attempted to use the work already executed upon Washington and above referred to; but careful reconnaissance developed the fact that the station Soper could not be made to look westerly, while only 3 miles northwest of it was a ridge nearly 100 feet higher, which commanded the entire country in every direction, and was the crest between the Chesapeake and Potomac. To remedy the mistake of 1845 in the later work cost the Coast Survey several thousand dollars. This is one of many such cases.

(3) In the older works upon geodesy  $30^\circ$  is prescribed as the smallest admissible angle in a primary chain. But since the date of most of these works the degree of attainable precision in the observations of directions has been largely increased, until the probable error of an observed direction in primary triangulation now rarely exceeds  $0''.2$ , and a change of  $0''.5$  in each angle of a triangle so badly shaped that one angle should be  $125^\circ$  and the other (opposite the base) only  $15^\circ$  would cause a change in the resulting sides of  $0^m.07$  for each 10 kilometers of length, and this difference would be largely reduced in the adjustment of any system of quadrilaterals of which such a triangle would form a part. While, therefore, the greatest care should be taken to obtain only "well-conditioned" triangles, yet the only case where the rule of nothing less than  $30^\circ$  should be rigidly adhered to is the case of a single chain admitting of no check between measured bases.

(4) An essential point in reconnaissance is the determination beyond the possibility of doubt of the intervisibility of every primary line essential to the scheme. This is often a very difficult and doubtful matter where the lines of sight are from 60 to 120 kilometers in length, and the weather is thick and hazy. Patient waiting for absolute certainty, however annoying or vexatious, or whatever hardship it may entail, is better than to allow any doubt to cloud reported results and perhaps cause serious delay and loss of time, which is money, to the observers who will succeed the reconnoitering party.

(5) Permanence of position for primary stations is an object to be carefully looked to, especially near the sea-coast where inroads of the ocean are possible, or in places where excavations may be made or buildings erected. In addition to the usual underground and surface marks, a round of angles upon prominent near objects, natural and artificial, will often serve to recover and identify a long disused station.

Not many years ago the writer had occasion to recover a primary station upon the island of Nantucket, originally made a quarter of a century before, by an assistant many years deceased. He was conducted by two residents of the island to the "exact site" of the former signal.

He had with him the original description, accompanied with angles upon certain churches and light-houses, of which four, he was informed, were the same he now beheld. On setting up his instrument and observing the angles he at once saw and said to the venerable men who had accompanied him that their memories were at fault. That was not the hill on which the station had been made. They scouted the idea of a mistake on their part, and were indignant that a stranger should be better informed than they who had spent their lives near the place. Paying no further attention to them, the instrument was removed to another ridge about a third of a mile distant, where, after half an hour of tentative observation, he directed his men to dig for the underground mark placed there 25 years ago, which they quickly discovered within 3 feet of the place he had indicated, to the unconcealed astonishment and mortification of his well-meaning but mistaken informants. This incident emphasizes the fact that the recorded description of the station, *without the observed angles*, would not have sufficed to recover the station, since the external aspect of the two hills was very much alike.

Assuming that geodetic surveys will, sooner or later, be extended over every part of the vast territory of the United States, it is of the highest importance that each triangulation point shall be so marked, and the record of the marking made so clear and definite, that the exact site may be recoverable during succeeding centuries. Topographical features may change with advancing population and wealth. New maps will be wanted. They may be quickly and readily supplied if only the old trigonometrical stations, or a part of them, may be reproduced. At this moment a new topographical survey of the State of Massachusetts is in progress. No new great triangulation

is necessary, for enough of the triangulation of 1832 to 1840 is found to furnish bases for supplying the new secondary and tertiary points required. For a more detailed description of methods of marking stations, see Appendix No. 9, Report for 1882, "Field work of the Triangulation," pages 159 and 160. Thus the officer making the reconnaissance for a triangulation should bear in mind, in selecting and making his stations, that his work is not for an immediate present purpose only, but that it may furnish bases for future centuries.

Primary triangulation presents different phases and encounters widely varied difficulties, depending upon the character of the country it traverses. Of these are—

1. Triangulation across bays and lakes, like Delaware or Chesapeake Bays.
2. Over open country, nearly level, as upon prairies.
3. Over a comparatively level farming country, partially wooded.
4. Over a hilly and wooded country, with parallel ridges of nearly the same elevation.
5. Over a hilly or mountain country, with elevations of irregular height.

Taking these up in the order named, the first brings up at once the limitations of lengths of sides, depending on the elevations to be found on each side of the bay or lake. Here it is important to consider a point essential to precision of observation. It is that no primary line, across water, or over a level country, should approach nearer than ten feet to the surface of the point where the line of sight becomes tangent to the curve of the earth's surface. It is apt to encounter a disturbed stratum of air very likely to deflect it laterally as well as vertically, as also very difficult to see through. Where the elevations of the two stations above the water between them, and their distance from each other, are approximately known, the question of their intervisibility may be quickly solved by an application of the following rule, which is easy to remember: It assumes a coefficient of refraction = 0.07. The curvature (and refraction combined) in feet is five hundred and seventy-four thousandths of the square of the distance in statute miles, or  $Cf = 0.574 D m^2$ , and recip-

rocall  $D m = \sqrt{\frac{Cf}{0.574}}$ : To apply this in practice, the distance from Egg Shoal to Long Shoal Point, near Cape Hatteras (Coast and Geodetic Survey Report for 1884, Sketch No. 5), is 22.3 miles. Both stations are 12 feet above Pamlico Sound. What elevation will be required at each end to carry the line of sight 12 feet above the surface of the water? As the heights of the two stations are equal the line of sight will be tangent to the earth's curve at the midway point, or 11.15 miles from each end. The height required will therefore =  $0.574 \times 11.15^2 = 71.4$  feet. If now the signal at Egg Shoal be raised to a height of 90 feet above the ground, where will the line of sight become tangent to the curve, and what elevation will be required at Long Shoal Point?

The tangent point will be  $\sqrt{\frac{90}{0.574}} = 12.52$  miles from Egg Shoal, or  $22.30 - 12.52 = 9.78$  miles from Long Shoal Point, where the height required will be  $0.574 \times 9.78^2 = 54.9$  feet. Therefore, a telescope 55 feet above the ground at either station will be sure to see a signal 90 feet above the ground at the other station, and the line of sight will be sure to pass at least 12 feet above the surface of the sound at the tangent point.

I give now an example of a different nature. In making the reconnaissance for extension of the primary triangulation across Massachusetts, it became important to make a station upon Cape Ann which should see Manomet Hill in Plymouth across Massachusetts Bay. A triangulation point of the Massachusetts State Survey, called Railcut Hill, had been found in that survey to be 205 feet above the sea, while Manomet Hill was 394 feet high. The distance between the two was 48.5 miles. Were they intervisible, or could they be easily be made so?

By the foregoing formula the "portee" or distance from Manomet to the tangent point was  $= \sqrt{\frac{394}{0.574}} = 26.2$  miles. This left 22.3 miles for the remaining distance and  $0.574 \times 22.3^2 = 285$  feet for the height required at Cape Ann. It was evident that a higher point than Railcut must be sought for. It was found at Thomson's Hill (Coast and Geodetic Survey Report, 1884, Sketch 3).

The general formula is: Curvature and refraction =  $(1 - 2m) \frac{K^2}{2R}$  where  $R$  = mean radius of the earth;  $K$  = distance, and  $m$  = coefficient of refraction. Log.  $R$  in feet may be taken as = 7.3199507, or in meters log.  $R$  = 6.8039618. The coefficient of refraction is assumed at 0.07  $m$ ,

which represents its mean value in the horizon from a large number of observations both on the sea-coast and in the interior. If  $K$  is expressed in feet or meters, then for any distance

Log. curvature and refraction in feet =  $\log. K^2 \text{ ft.} + 2.31352$ .

Log. curvature and refraction in meters =  $\log. K^2 \text{ m.} + 2.82951$ .

The following tables represent the values of these quantities in feet for each mile of distance up to 80 miles, and for meters in each kilometer of distance up to 80 kilometers. The close approximation to truth of the rule first given may be seen by comparing its result with that of the table;  $0.574 \times 80^2 = 3673.6$  feet, or within 1 foot of the tabular value for so great a distance as 80 miles. Its value in reconnaissance consists in its ready application on the ground, when away from log. tables and reference books:

*Tables of values of curvature and refraction.*

Distances in miles, curvature and refraction in feet.								Distances in kilometers, curvature and refraction in meters.							
M.	Feet.	M.	Feet.	M.	Feet.	M.	Feet.	K.	Meters.	K.	Meters.	K.	Meters.	K.	Meters.
1	0.57	21	253.06	41	964.61	61	2135.23	1	0.07	21	29.78	41	113.53	61	251.30
2	2.30	22	277.74	42	1012.25	62	2205.60	2	0.27	22	32.69	42	119.13	62	259.60
3	5.17	23	303.56	43	1061.03	63	2277.52	3	0.61	23	35.73	43	124.87	63	268.05
4	9.19	24	330.53	44	1110.95	64	2350.40	4	1.08	24	38.90	44	130.75	64	276.63
5	14.35	25	358.64	45	1162.02	65	2424.43	5	1.69	25	42.21	45	136.76	65	285.34
6	20.66	26	387.90	46	1214.24	66	2499.61	6	2.43	26	45.65	46	142.90	66	294.19
7	28.12	27	418.31	47	1267.61	67	2575.93	7	3.31	27	49.23	47	149.18	67	303.17
8	36.73	28	449.87	48	1322.12	68	2653.40	8	4.32	28	52.95	48	155.60	68	312.29
9	46.49	29	482.59	49	1377.78	69	2732.01	9	5.47	29	56.80	49	162.15	69	321.54
10	57.40	30	516.46	50	1434.59	70	2811.77	10	6.75	30	60.78	50	168.84	70	330.93
11	69.46	31	551.47	51	1492.55	71	2892.68	11	8.17	31	64.90	51	175.66	71	340.45
12	82.66	32	587.62	52	1551.66	72	2974.74	12	9.72	32	69.16	52	182.61	72	350.10
13	97.00	33	624.92	53	1611.92	73	3057.95	13	11.41	33	73.55	53	189.71	73	359.90
14	112.49	34	663.36	54	1673.33	74	3142.31	14	13.23	34	78.07	54	196.93	74	369.82
15	129.12	35	702.94	55	1735.89	75	3227.83	15	15.19	35	82.83	55	204.29	75	379.89
16	146.90	36	743.67	56	1799.59	76	3314.49	16	17.29	36	87.53	56	211.79	76	390.09
17	165.83	37	785.55	57	1864.43	77	3402.29	17	19.51	37	92.46	57	219.42	77	400.42
18	185.92	38	828.59	58	1930.41	78	3491.23	18	21.88	38	97.52	58	227.19	78	410.89
19	207.15	39	872.78	59	1997.54	79	3581.32	19	24.33	39	107.72	59	235.09	79	421.49
20	229.53	40	918.12	60	2065.81	80	3672.55	20	27.01	40	108.06	60	243.13	80	432.23

*Values of curvature and refraction for short distances.*

Distances in yards, curvature and refraction in feet.						Distances, curvature, and refraction in meters.					
Yards.	Feet.	Yards.	Feet.	Yards.	Feet.	Meters.		Meters.		Meters.	
						Dist.	Curv. and Refr.	Dist.	Curv. and Refr.	Dist.	Curv. and Refr.
50	.0005	550	.0560	1050	.2042	50	.0002	550	.0204	1050	.0744
100	.0019	600	.0669	1100	.2241	100	.0007	600	.0243	1100	.0817
150	.0042	650	.0783	1150	.2450	150	.0015	650	.0285	1150	.0893
200	.0074	700	.0908	1200	.2668	200	.0027	700	.0331	1200	.0972
250	.0116	750	.1042	1250	.2895	250	.0042	750	.0380	1250	.1055
300	.0167	800	.1186	1300	.3131	300	.0061	800	.0432	1300	.1141
350	.0227	850	.1339	1350	.3376	350	.0083	850	.0488	1350	.1231
400	.0296	900	.1501	1400	.3631	400	.0108	900	.0547	1400	.1324
450	.0375	950	.1672	1450	.3895	450	.0137	950	.0609	1450	.1420
500	.0463	1000	.1852	1500	.4168	500	.0169	1000	.0675	1500	.1519



In an open level country, where no natural or artificial obstacles interfere, the triangulation may be laid out with reference only to the heights of structures erected and the geometrical conditions involved. If a uniform height above ground of 70 feet be assumed for the instrument and signal, and the line of sight is made to pass 10 feet above the surface at the tangent-point, a single series of nearly equilateral triangles with sides about 20 miles in length may be made. This would be the best system to adopt in a level wooded country where avenues are required on every line, as in a chain of triangles across the Florida Peninsula, where the triangulation starts from a base on the Atlantic side, to meet and be checked by another base upon the Gulf side. But in a level and open country a system of quadrilaterals with sides of about 15 miles and diagonals of 21 will only require one more station for every 30 miles of progress, and will more than gain this expense and labor in the additional precision acquired.

In a level country which is cultivated and where wood land is valuable, very careful reconnaissance is necessary to avoid striking insuperable obstacles, as houses and ornamental trees. If the country is intersected by navigable creeks, as upon the sea islands of South Carolina and Georgia, chains of secondary triangles along the water-courses have proved the best resource. About ten years ago I planned a method of connecting the Atlanta and Edisto Bases, by extending a chain of triangles from near "Currahee" Station, in North Georgia, along the valley of the Savannah River, with stations upon the hills on each side as far as Augusta, where the "rolling country" ends, and thence by measurement upon the Augusta and Port Royal railroad, a distance of 80 miles, to a connection with the coast triangulation at Beaufort, S. C. This method of measurement was proposed by Assistant J. E. Hilgard in Appendix No. 9, Report for 1867. I have always considered it practicable upon railroads having only a slight percentage of curvature, where the direction may be carefully kept up by angular measurements and observed azimuths. The railroad here named has one straight line of 45 miles in length, which is half the whole distance to be measured.

In a hilly and wooded country, with parallel ridges of nearly the same elevation, the skill and resources of the reconnoitering officer are severely tried. A secondary triangulation may be easily laid out, since the sides may be carried from ridge to ridge across the intervening valleys. But the longer sides required for primary triangles must cross these wooded ridges at various angles, and to ascertain with certainty the intervisibility of distant points or the possibility of rendering them intervisible is often exceedingly difficult.

The best method is that of an approximate secondary triangulation with a gradiometer or (if observations must be made from tops of trees) with a sextant, starting, of course, from some known base. A computation of approximate triangle sides, combined by linear co-ordinates from the meridian of the starting point and kept up as the reconnaissance progresses, will best develop both the possible triangles and the geometrical figure best suited to the ground. Approximate vertical angles will give differences of level close enough to decide on elevations likely to be needed to see over intervening ridges, and also to ascertain which are the highest crests of each ridge. Proceeding with care in this manner, it will be found that certain points are so situated, both in position, elevation, and accessibility, that they *must be* primary stations. Others again present equal advantages, and *may be* chosen, that is, some one of them may be, while others, which had appeared at the outset as very prominent from their abrupt and sharp elevation above the general level, fade into insignificance before long and gradual slopes, which finally overtop all others.

Keeping in mind the principle heretofore set forth, that "primary stations should occupy the highest crests," and patiently laboring to discover and identify what are the highest crests, it will be found, when these are discovered and connected by approximate linear co-ordinates, that they are susceptible of such linear connections as will, at least cost of time and money, develop into the best obtainable system of primary triangulation. Hence follow two rules for reconnaissance in such a difficult country as I am describing, viz: First, search for the crests or highest points of the highest ridges and connect them by an approximate series of small triangles from a known base. Second, endeavor to render the selected points intervisible by avenues across wooded intervening ridges, or by building high enough to see over them, or both combined. I would cite Northern Alabama as a notable example of the kind of country I have described.

Primary triangulation over a hilly or mountain country with isolated summits of unequal

height will, as a rule, admit of the fewest possible number of stations with the longest possible sides, as in the great "Davidson" quadrilateral in California, where one diagonal is 143 miles long and the area of the quadrilateral is over 6,600 square miles. These great distances are not attainable east of the Rocky Mountains, as neither topographic nor atmospheric conditions admit of them; but the principle of the choice of the highest summits with the fewest possible number of stations has been carried out in the primary triangulation along the coast from Narragansett Bay to the Bay of Fundy, a distance of about 400 miles, covered by 9 quadrilaterals, or about 45 miles to each quadrilateral.

The conditions governing the choice of stations in the chain of triangles connecting the Kent Island and Atlanta Bases were of an entirely different character. The very level and densely wooded character of the sea-coast south of Chesapeake Bay forced the great chain of primary triangulation back to the first range of hills parallel to the coast, which was the Blue Ridge, and the plan adopted was to make the back tier of stations upon the Blue Ridge and the front tier nearest the coast upon the outlying foot-hills as far southeasterly as intervisible stations could be found. From these connecting chains of smaller triangles were to be made with the sea-coast bases at Bodies', Edisto, and Dauphin Islands. As a matter of necessity nearly every quadrilateral here took an elongated form, with the longer sides along the mountain ranges and parallel to the sea-board.

Omitting the smaller series required to reach the mountains from Annapolis, the distance of 602 miles between the two bases is covered by 16 quadrilaterals, having an average length of about 38 miles from each long side and 25 miles for the short side of each quadrilateral, with the longest side 82 miles and the shortest side 20 miles.

In this form of reconnaissance, as in that preceding it, the first step to be taken is a general examination of the country, fixing its most prominent features in the mind of the observer, most careful watch being kept of the different phases presented by the principal elevations as seen from different points of view. Here rapid outline sketches inserted in the note-book will be found of great service in identifying the same point under different aspects.

This general reconnaissance also helps in acquiring a habit of *self-orientation*, by which, on reaching a mountain summit, with an extended *coup d'œil*, the eye will at once recognize and correctly locate the most salient points of view.

This is followed by a close reconnaissance, with the advantage that certain points of special prominence have been recognized as belonging to the class of stations that *must be* taken, thus reducing the work to an examination of those which *may be* taken. As these must of necessity bear certain geometric relations to the "must-be" stations, the general region to be more carefully looked to is narrowed, and the work to be done more sharply defined.

The best method is that described on the preceding page. Start from a known base, and make an irregular approximate triangulation; that is, wherever a cleared hill presents itself which is accessible visit it and observe angles upon all prominent objects in sight. If no known station is visible, observe the magnetic meridian as a reference point. The best instrument for the purpose is the gradienter, which is light, small, and compendious, enabling one to get very good approximate elevations with its micrometer. Early in the work some of the points seen and observed from the known stations will be observed, and it will be possible to compute the positions of one or more of the points visited.

#### THREE-POINT PROBLEM.

If only the positions may be known to within 150 meters, it will be sufficient to insure their presence within the field of view of the telescope if they are in sight. The "three-point" problem may be used to advantage if as many as three or more known points are approximately observed. Where the known positions are projected on a reconnoitering map, the position of the point of observation may be approximately ascertained by plotting the observed angle upon tracing muslin and fitting the three or more diverging lines to hit the observed station, as usual in hydrographic work, with the three-arm protractor. But where the position of the point is wanted in prolonging the reconnaissance, it may be computed. An example is here given.

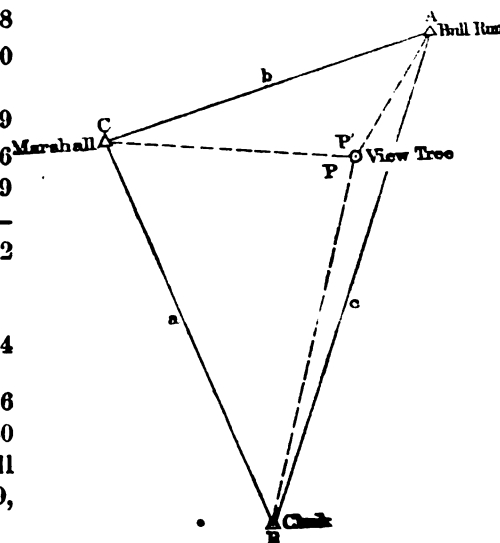
At View Tree Mountain, near Warrenton, Va., the following angles were observed upon three known stations—Bull Run, Clarke, and Marshall. Required, the position of View Tree:

*At View Tree.*

		Meters.	
1. Bull Run = A = 0 00	Bull Run—Clarke = c = 68461	log = 4.83544	
2. Clarke = B = 162 19	Marshall—Clarke = a = 54435	log = 4.73588	
3. Marshall = C = 243 30	Marshall—Bull Run = b = 44916	log = 4.65240	

Formula of Reduction (1)  $\cot X = \cot R \left( \frac{a \sin P'}{b \sin P \cos R} + 1 \right)$  (2)  $Y = R - X$

Known angle ACB = C = 86 33 4	
Observed angle BPC = P = 81 11 0 and CP'A = 116° 30' $\triangle R = 360^\circ - P - P' - C = 75^\circ 45'.6$	
Marshall—Clarke = a = 54435	log = 4.73588
Marshall—Bull Run = b = 44916	co-ar = 5.34760
P' = 116 30	sin = 9.95179
P = 81 11	co-ar sin = 0.00516
R = 75 45.6	co-ar cos = 0.60909
	<hr/>
+ 4.4619	= 0.64952
+ 1.	
<hr/>	
5.4619	= 0.73734
R = 75 45.6	cot = 9.40446
cBP = X = 35 48.5	cot = 0.14180
cAP' = Y = 39 57.1	Whence the angles at Marshall
PcB = 63 00.5	are deduced and ACP' = 23° 32'.9,
	and the sides may be computed as usual.



#### TWO-POINT PROBLEM.

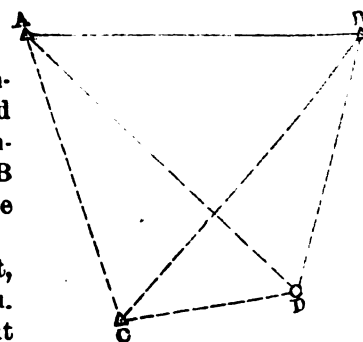
It sometimes happens that only two triangulation points upon elevated peaks, difficult of access, are visible from a comparatively level and lower region where a reconnaissance is being made to find the best points to connect with them. Where any two lower hills see each other, and also the two higher stations, the direction and distance between which is known, the positions of the two unknown points may be determined, as follows: Let A and B represent the two known points, and C and D the two unknown ones.

At C measure ACB, ACD, BCD.

At D measure CDA, CDB, ADB.

Assume a length for the side CD and on this assumed base compute the triangles ACD and BCD; then, with two sides and included angle given, compute ACB and ADB. Having thus found the angles in the quadrilateral ABCD, substitute the true length of AB and re-compute the triangles, thus obtaining the true position of the points C and D.

Proceeding in this manner, from the known data at the outset, it will be possible in any country like that here described to accumulate approximate data which will enable the observer to lay out a scheme of triangulation best adapting itself to the configuration of the country while also best conforming to the requisite geometric conditions.



I have found the method of keeping up a system of linear co-ordinates so useful in this work, that I add examples of its prosecution and use. Instead of using the azimuths of the triangle sides observed I have used their angles with the assumed meridian for greater convenience of computation.

The example given is from a reconnaissance in Northern Alabama, to determine the best positions for the stations next west of the known stations, Wilson, Rowe, and Smithers; also, as the reconnaissance progressed, as to the possibility of rendering intervisible the point "Tanyard" from Wilson and Rowe. Rowe is made the starting point, and the directions from that point are angles with its meridian. All other directions are taken as angles with parallels to the meridian of Rowe. The distances are taken from computations of approximate triangles, which are here omitted.

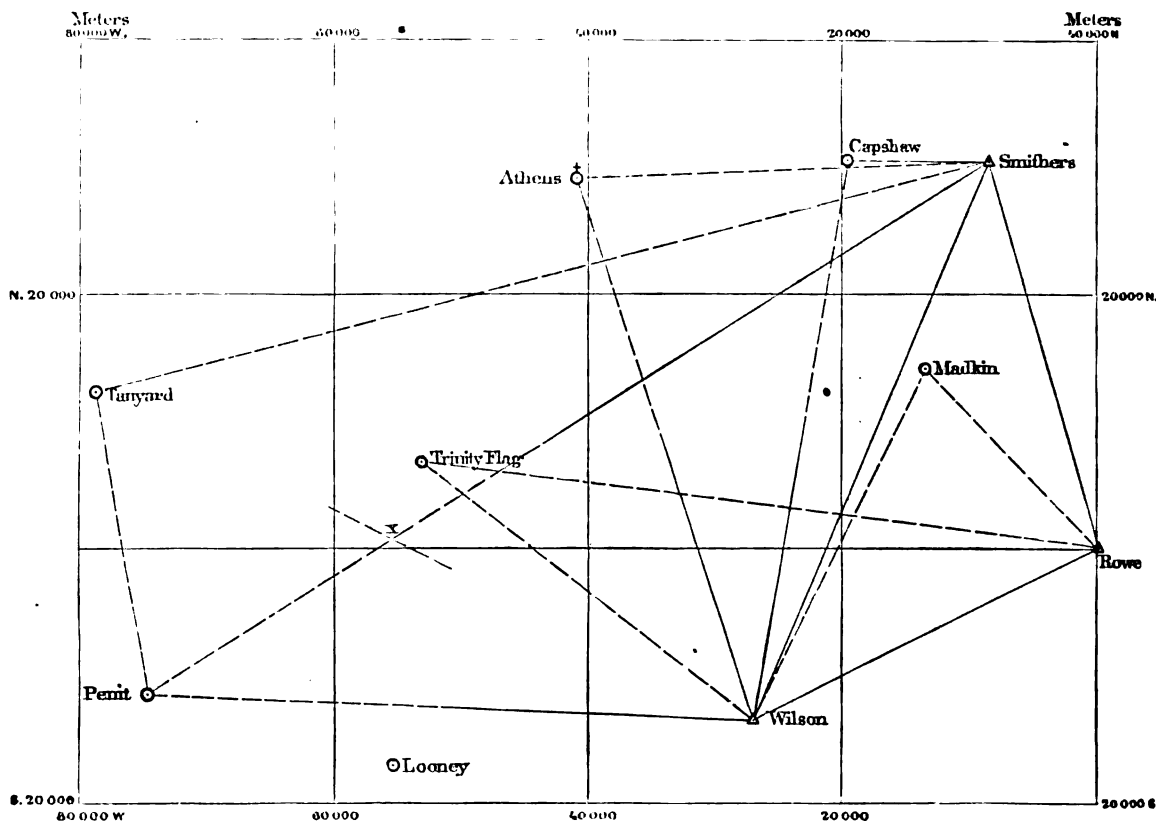
*Computation of linear co-ordinates.*

[D = directions. K = distances in meters.]

[D = directions. K = distances in meters.]									
From where to where.	D		Log sin D	Log cos D	Log K	K cos D	Log K cos D	K sin D	Log K sin D
		° ' "				Meters.		Meters	
Rowe to Smithers.	NW.	15 20 48	9.42269	9.98423	4.50326	30725	4.48749	8432	3.92594
Wilson.	SW.	63 39 06	9.95236	9.64721	4.47857	13359	4.12578	26973	4.43093
Capshaw.	NW.	32 22 23	9.72870	9.92664	4.56335	30902	4.48999	19591	4.29205
Madkin.	NW.	37 43 57	9.78673	9.89811	4.25342	14175	4.15153	10969	4.04015
Trinity Flag.	NW.	82 25 34	9.99619	9.11993	4.72971	7073.5	3.84964	52199	4.72590
Wilson to Trinity Flag.	NW.	52 04 32	9.89698	9.78861	4.52173	20433	4.31034	26224	4.41871
Madkin.	NE.	30 10 00	9.70115	9.93680	4.50309	27535	4.43989	16004	4.20424
Looney.	SW.	82 13 30	9.99599	9.13124	4.46539	3950	3.59663	28932	4.46138
Penit.	NW.	87 25 14	9.99956	8.65326	4.67963	2152	3.33289	47774	4.67919
Capshaw.	NE.	9 28 10	9.21622	9.99404	4.65198	44261	4.64602	7382.5	3.86820
Smithers.	NE.	22 48 39	9.58848	9.96463	4.67965	44084	4.64428	18541	4.26813
Athens church.	NW.	18 08 00	9.49308	9.97788	4.65223	42668	4.63011	13974	4.14531
Smithers to Capshaw.	NW.	89 05 33	9.99995	8.19971	4.04765	176.7	2.24736	11158	4.04760
Athens church.	SW.	87 30 25	9.99959	8.63847	4.51249	1415.7	3.15096	32515	4.51208
Penit.	SW.	57 41 39	9.92896	9.72790	4.89465	41932	4.62255	66315	4.82161
Tanyard.	SW.	75 49 30	9.98657	9.38896	4.86082	17774	4.24978	70370	4.84739

Combining the above results, we obtain the following table of the number of meters that each point is north, south, or west of Rowe:

Stations.	N.	S.	E.	W.
	<i>Meters.</i>	<i>Meters.</i>		<i>Meters.</i>
Rowe.	0	0		0
Smithers.	30725.0			8432.0
Capshaw.	30902.0			19590.5
Wilson.		13359.0		26973.0
Penit.		11207.0		74747.0
Tanyard.	12951.0			78802.0
Trinity Flag.	7074.0			53198.0
Madkin.	14175.0			10969.0



UNITED STATES COAST AND GEODETIC SURVEY.

Sketch showing Reconnaissance for extension of Primary Triangulation in Northern Alabama.

Scale =  $\frac{1}{600,000}$ 

These positions when projected in their appropriate squares, as in the sketch, show that Tanyard must see Wilson in order to complete the scheme of triangulation up to the side Tanyard-Penit. This line crosses Trinity Ridge about 4 miles SSW. from Trinity flag-tree, which is near the northern end of the ridge. The whole ridge is heavily wooded and broad, and cannot be seen over from the ground at either Wilson or Tanyard. From the table we obtain directions and distances from Tanyard to Wilson and Rowe:

Tanyard N.	12951 W. 78802	Tanyard	= N. 12951 W. 78802
Wilson S.	13359 W. 26973	Rowe	= 0 0
Tanyard north of Wilson = 26310 W. 51829	= 4.71457	Tanyard north of Rowe = 12951 W. 78802	= 4.89654
	= 4.42012		= 4.11230
Wilson to Tanyard NW. $63^{\circ} 05' 10''$	tang = 0.29445	Rowe to Tanyard NW. $80^{\circ} 40' 00''$	tang = 0.78424
	sin = 9.95021		9.99421
Distance Wilson to Tanyard = 58125 meters	= 4.76436	Distance to Rowe to Tanyard	= 79860 meters = 4.90233
or 36.12 miles.		or 49.62 miles.	

It will be noticed upon the sketch that the line most needed (Tanyard-Wilson) intersects the line Smithers-Penit very close to the top of Trinity Ridge. Calling the point of intersection  $x$ , we get approximate distances by computing the two triangles—

Smithers-Wilson	= 4.67965	Smithers-Tanyard	= 4.86082
$x = 59^{\circ} 11'$ (concluded)	co-ar sin = 0.06610	$x = 120^{\circ} 49'$	co-ar sin = 0.06610
Smithers = $34^{\circ} 53'$	sin 9.75733	Smithers = $18^{\circ} 08'$	9.49308
Wilson = $85^{\circ} 56'$	sin 9.99756	Tanyard = $41^{\circ} 03'$	9.81738
Wilson — $x = 31848$ meters.	= 4.50308	Tanyard — $x = 26303$	= 4.42000
Smithers — $x = 55375$ meters.	= 4.74331	Smithers — $x = 55501$	= 4.74430

The approximate heights above sea are—

Rowe = 1402 feet, and at Smithers the approximate zenith distance of tops of trees at  $x = 90^\circ 24' 56''$ , which gives approximate elevations of tops of trees at  $x = 870$  feet.

Wilson = 1185 feet.

Smithers = 1490 feet, Telescope at Wilson = 70 feet above station point, or 1255 feet above sea.

Tanyard = 850 feet, Heliotrope at Wilson, 85 feet above station point, or 1270 feet above sea.

Telescope at Tanyard, 101 feet above station point, or 951 feet above sea.

Heliotrope at Tanyard, 106 feet above station point, or 956 feet above sea.

A reduction of these quantities shows that the line Wilson-Tanyard will pass about 40 feet above the trees upon the intervening ridge, as represented by the point  $x$ , and the line is practicable at the elevations named.

Approximate computations and tables like those here given are of very great service where long lines are sought for, in insuring certainty of pointing the telescope in thick and hazy weather. As has been before stated, approximations to within 100 to 150 meters will suffice to insure that the point looked for is within the field of view, and much tedious "sweeping" and possible doubt as to the point looked for being visible will be avoided.

Of course in the level plains and prairies, and the densely wooded swamps of the West and South, no such methods of even approximate precision are possible, and only a careful examination of every part of every line will render intervisibility certain. Close examination of the best local maps obtainable will always show where the various and diverging water-courses head, and the highest ground will, as a rule, be found in that vicinity, and will help to narrow the field of personal research.

In all the different forms in which primary triangulation is to be laid out, and whatever may be the ground to be covered, the observer needs to set before himself clearly the points to be aimed at, the principles to be applied, and the methods to be pursued. A quick eye and ready perception, with a habit, natural or acquired, of self-orientation—by which I mean the faculty of knowing at any point visited for the first time just where to look for other points requisite to the work in hand—will best help to securing a full knowledge of the country, and will suggest the best methods of laying out the work.

Very full notes and sketches should accompany every journal of reconnaissance. Every point which may aid a successor should be carefully noted and recorded. Among these some of the most important are the means of access; condition of roads or paths to be traveled; what tracks must be opened in the final occupation of the station; the estimated cost in time, labor, and money of occupying the station; probable amount of damages to be paid, if any; names of the persons living near the station, and a sketch showing their residences; the name and residence of the owner, and whether his views as to the use of his land are favorable or otherwise; the nearest post-office, and place from whence supplies may be procured; whether the party occupying the station may be boarded near it, or if an encampment will be requisite; and (if a heliotrope or night-signal, or both, are likely to be needed) where a proper man for the work may be found. Indeed it is impossible to be too minute in descriptions of the selected stations.

The best instruments are a gradienter, with level, micrometer, and magnetic needle. This small and compendious instrument comprises in itself every essential requisite for a reconnaissance where observations may be made upon the ground, and the sides do not exceed 25 miles in length. For longer sides it will be best to add a reconnoitering telescope and stand. A tape-line 100 feet long, of the kind which has wires woven into the marked linen, is also needed.

For reconnaissance in a wooded country, where observations must be from tree tops, a small 6-inch sextant, with telescope attached, of the form now most used in hydrography, will be better than the usual pocket sextant. This and a good spy-glass and a prismatic compass are all the instruments needed. A set of spurs, like those used by telegraph linemen, will be found useful, as will also a coil of manila rope, about 100 feet long, and strong enough to bear the weight of a man, with a ball of marline, and another of strong twine, and a supply of different colored material for flags. A horse and covered wagon, with one active, intelligent man, of the class who can "turn their hands to anything," and who are not afraid to go aloft, will complete the outfit requisite for a reconnoitering party.

## SELECTION OF STATIONS FOR SECONDARY AND TERTIARY TRIANGULATIONS.

Reconnaissance for selection of stations to be occupied as secondary triangulation points involves a search of a very different nature from that we have been considering. While primary triangulation covers the country with the fewest possible number of triangles, each having the largest possible area, the object of the secondary work is to multiply stations for the use of the topographer and hydrographer.

As these stations abut upon and are connected with the primary stations, and any error introduced will not be multiplied and extended, the same elaborate methods of observation are not necessary. The length of triangle sides rarely exceeds 25 kilometers, and the average length is not more than 10 kilometers.

The reconnaissance for a secondary triangulation becomes, therefore—

(1) A selection of points of the first order which shall start from long primary bases, and shorten the sides of the triangles while commanding the country to be surveyed in detail by the topographer and hydrographer. These points should be all occupied, and the triangles should close with average errors not exceeding one to two seconds to an angle.

(2) Secondary triangulation points of the second order, based upon the primary and first order points, and so located as to command every prominent object visible, or which may be rendered visible for observation from two or more stations. Sufficient precision will be attained if the second order triangles close within three seconds to an angle.

(3) Tertiary triangulation points, to be observed upon and not occupied. These should include every prominent point, such as church spires, cupolas, chimneys, flags in prominent trees, indeed everything which will multiply useful data for the topographer to have correctly plotted on his plane-table sheet, or the hydrographer to “angle” upon in determining the position of his boat while sounding. Of these points there cannot be too many, and in a difficult country, as upon portions of the bold and rocky shores upon the Maine coast, or upon the Pacific, every device possible to multiply these “tertiary points” should be tried. Large white crosses and triangles painted upon rocky bluffs make very useful points. Flags in prominent trees also. In the case of using trees they may be marked for future reference by cutting large triangles through the bark and into the wood upon the tree at its base.

The officer charged with this work should specially bear in mind that his duty does not consist in laying out well-shaped and symmetrical series of triangles. The form of each secondary triangle is of comparatively little consequence, except where it forms part of a system for extending a work over a region where no primary triangulation is carried, as upon parts of the Florida coast. In all other places symmetry of form should be made to give place to the multiplication of tertiary points from well-selected secondary ones.

Where possible *three* lines from secondary stations should be made to converge upon each tertiary point, in order to check errors of observation which may possibly creep in, and which could not be detected where there is only a single triangle.

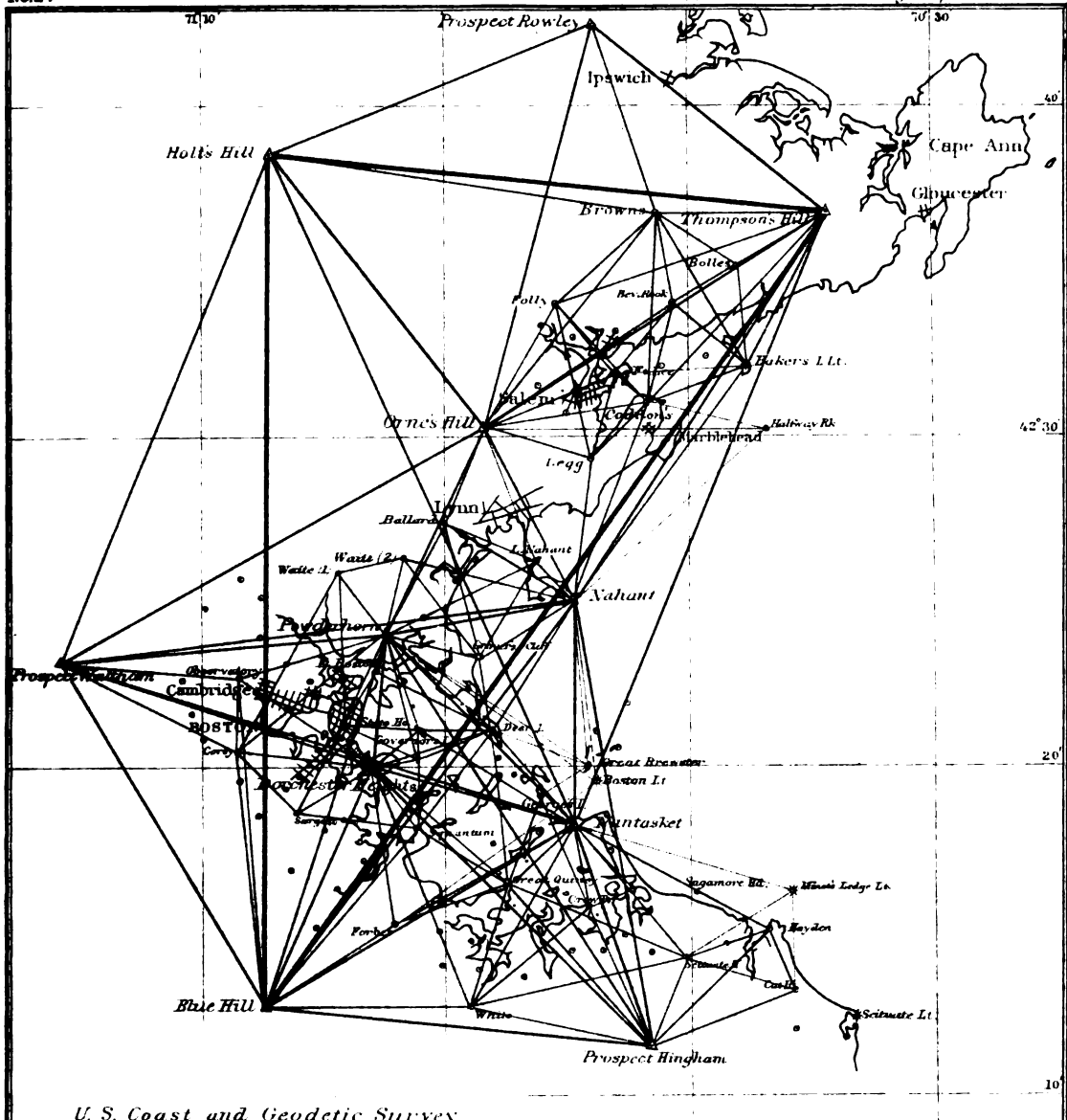
Single readings, direct and reversed, are sufficient in observing upon tertiary points where the instrument used reads to 10 seconds.

Very careful descriptions should be made in the note-book of both reconnoitering officer and observer of all tertiary points observed upon. This is of great importance where the triangulation is largely in advance of the other parties. But it is also necessary in view of future surveys in future years. Prominent tertiary points observed in the Massachusetts Trigonometrical Survey, made between 1834 and 1840, are being identified and used in the resurvey of that State now in progress.

The sketches Nos. 27 and 28, which follow, illustrate all the above varieties of secondary triangulation. In the first, upon the coast of Massachusetts, the country is hilly and comparatively open, and large numbers of tertiary points are easily determined.

In the second, upon the coast of South Carolina, no natural elevations of 20 feet can be found, while forest trees abound and points for the topographer and hydrographer are had with difficulty.\* But, as a rule, there is a triangulation point for every square mile.

\* Attention is called to the use of the wide avenues opened upon the primary lines in furnishing secondary bases.



U. S. Coast and Geodetic Survey

Sketch showing

Secondary Triangulation

of Boston Bay

Scale  $\frac{1}{400,000}$

————— Sides of Primary Triangles  
 ————— Secondary " of First Order  
 ————— " of Second " of Second  
 ————— " of Third " of Third

Triangle sides to Tertiary Points and their names are omitted that sketch may not appear complex

Statute Miles

5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20







201

In this memoir I have avoided theoretical discussions and only set forth practical details. For full discussion of the geometrical and mathematical principles involved, I refer to Assistant Schott's Appendix 20, Report of 1876, on the "Adaptation of Triangulation to the various conditions of configuration and character of the surface of the country, and other causes." Also to "Clarke's Geodesy," vol. 1, 8vo., Oxford, 1880; and to "Jordan's Geodesy," vol. 2, 8vo., Stuttgart, 1877; and "Principal Geodetic Points, and their Co-ordinates," vol. 1, 8vo., Berlin. The two last-named works are in German.

In conclusion, the writer desires to say that he has embodied in this paper an experience of over forty years, covering every department of Coast and Geodetic work. If he has succeeded in bringing together information useful to his comrades and successors, he will have accomplished the end sought for and will be amply repaid.

O. O. BOUTELLE,  
*Assistant.*

The SUPERINTENDENT  
U. S. COAST AND GEODETIC SURVEY.  
H. Ex. 18—61



## APPENDIX No. 11.

### A PLEA FOR A LIGHT ON SAINT GEORGE'S BANK.

By HENRY MITCHELL, Assistant,

To our late Superintendent, Prof. J. E. Hilgard, as a member of the Light-House Board, I made a communication some months since concerning the necessity of lights upon the summit of Saint George's Bank. Perhaps in all my experience as a coast surveyor I have never felt that I was doing more Christian service than when compiling the notes that I beg leave to repeat below.

Although the position of Cape Sable was accurately determined in 1755, the whereabouts of the George's was still a mystery at the beginning of this century. Dr. Franklin had declared its latitude, and his conclusion was correct, but he did not venture to mention its longitude, and the charts that adopted his latitude put the shoals 35 miles out in longitude. One has but to glance at the chart to guess how much mischief such an error of position must have caused. The charts of that time did not agree, happily, so that the navigator did not trust them, as he now does, implicitly. But as the charts improve, the day and night marks of shoals become not less but more essential. The navigator has now a chart that he knows is correct, and he lays down his course with the slightest possible deflection from a straight line, and as he shaves the dangerous reef or shoal he expects to find a warning mark, for there is time and property and life to be saved, and the whole community shares the risk and the danger. Should it not be a surprise then to us that the greatest danger on our coast, and the one feared by the largest number, perhaps, of seamen, is unmarked and undistinguishable except by its hideous roar when the ship is already within its breakers?

Saint George's Bank lies at the threshold of the Gulf of Maine, and its summit is called distinctively "George's Shoal," or "The Georges." Twenty miles westward of the Georges is the "Cultivator Shoal." Upon the Georges there are two spots of 12 feet given by chart, while upon Cultivator Shoal there is not less than 18 feet. (See Annual Report Coast and Geodetic Survey, 1879, Appendix No. 10, for physical conditions.)

If we draw a line from the Nantucket South Shoal light-ship to Brazil Rock, off Cape Sable, we find Cultivator Shoal 12 nautical miles outside (seaward) of this line, and the 12-foot limit of the George's 22 miles outside of the same line. These shoals then are outside of the Gulf of Maine and beyond the general trend of the coast.

Again, if we draw a line from Hatteras to Cape Sable, which passes 150 miles seaward of Sandy Hook (at the apex of the great bay, of which our line is the chord), we still find George's Shoal a salient protruding into the ocean.

It is 100 miles from the nearest land, Chatham, Cape Cod. Its situation relative to the continent is like that of Sable Island, and, like this island, it would long ago have been lighted if *dry land*. As a shoal it is far more dangerous than it would be as an island, and therefore it is shunned and feared except by fishermen who are obliged to brave its dangers.

If we draw a line from Nantucket light-ship to Cape Race (Newfoundland), it passes about 6½ miles outside (southward) of the Cultivator Shoal, but it passes directly over George's Shoal between the 18 and 24 foot contours, where the lightest draught vessel can rarely pass in safety because of breakers. Thus we see that *George's Shoal, an unmarked danger, lies in the shortest water route between New York and Liverpool* (and other ports of Northern Europe), and the fear of it

makes voyages longer and more anxious. But for this, vessels that now go wide out to sea, making a great detour, would run coastwise within Sable Island, which is well lighted. As it is, unless Halifax or some other port of Nova Scotia is to be visited, vessels run far southward. Still, even under present conditions, vessels from Europe haul in to make Nantucket light-ship, and if they do so skilfully they pass within 10 miles of the 12-foot spot on George's Shoal.

A line from Nantucket light-ship to Sable Island eastern light passes 10 or 11 miles outside of the Cultivator Shoal and 4 or 5 miles outside of George's. Now, parallel to this line at a safe sighting distance from Nantucket Shoals and Sable Island lights, a ship's course would still be only 10 miles off George's—*near enough to see an ordinary light-ship*, if our Government could not afford a more generous spark.

It is not alone the direct danger from this *lion in the path* that we would present as a reason for a warning light, but the advantage also of the light itself as a guide. With this warning and guiding light the European commerce of New York would gain time and reduce its risks; and in less measure, but still to an important degree, the ocean commerce of Boston, Salem, Newburyport, Portsmouth, Portland, Bath, Bangor, Saint John, &c., would be benefited.

In our remarks, thus far, we have not considered the fishing fleet.

One easily sees that the shortening of time, however slight, and the diminution of risks however small, as affecting the grand ocean commerce, must command attention. But it is not so obvious that small fishing vessels that seek these shallow waters can receive benefits from a local light to any extent deserving consideration, especially as their fishing ground covers 500 square miles of "George's Bank."

It must be remembered, however, that the fishing fleet of the Gulf of Maine numbers over 600 sea-going vessels of 30 to 300 tons each, with average, perhaps, 70 tons. Of these there may be at times 400 fishing on the George's or crossing the shoals *en route* to more distant grounds. These 400 vessels carry about 4,000 men, all working on shares, and presenting the most just and most useful form of co-operative industry that our country offers. The vessels seeking Provincetown Harbor, the nearest good shelter, sometimes number 500 by actual count.

We may conceive of the Georges fleet (of 100 vessels perhaps) as gathering in towards the summit of the Bank, as near as would be safe, without very definite boundaries or uniform distribution of vessels. The light that we propose, and the powerful horn placed at the nucleus of this fleet, would reach a very considerable part of the vessels and serve to *maintain their reckoning*. In the present state of things not only do skippers form a very indefinite idea of the whereabouts of the shoals when fresh from port, but after a few days' cruising they not unfrequently lose their reckoning altogether. We submit that the sight of a light on George's Shoal, or the sound of a horn from that much dreaded spot, would enable many a fishing vessel to stand away for port, when the storm threatens, instead of attempting to ride out the gale at anchor or lie to with fear of dragging upon the shoal or fouling with another of the fleet. "Though none of our fisheries are exempt from peril, it may safely be said that the winter cod fisheries on George's Bank and the trawl fishery, especially that for haddock and halibut in winter, are the most dangerous of all." These words we quote from the "Fisherman's Own Book," and from this book, and other sources, we learn that in 1879 Gloucester alone lost 13 vessels and 143 lives; in 1882, 4 vessels with 51 lives, and in 1883-'84 18 vessels and about 180 lives. I give the figures for a few years only and only for the Gloucester fleet, which covers but two-thirds of the interest of fisheries on the Georges, perhaps.

It is impossible to say what proportion of these vessels might have run into port, had they known their exact whereabouts, or how many times, for fear of being caught thus in a dangerous neighborhood, the fleet has unnecessarily left the fishing ground. One need not speculate upon the economical relations of the case, the story is bad enough as it stands!

Here we have a breaking shoal lying exactly on the shortest route from New York to the British Channel, and near the routes of all the ocean commerce of Massachusetts Bay and the Bay of Fundy, with no warning light! Moreover, it is the resort of a great fleet of winter fishing vessels that lose their reckoning, and thus their chance of making a safe harbor in the gale, because no signal upon the shoal gives them the correct bearings and distances of the numerous ports which

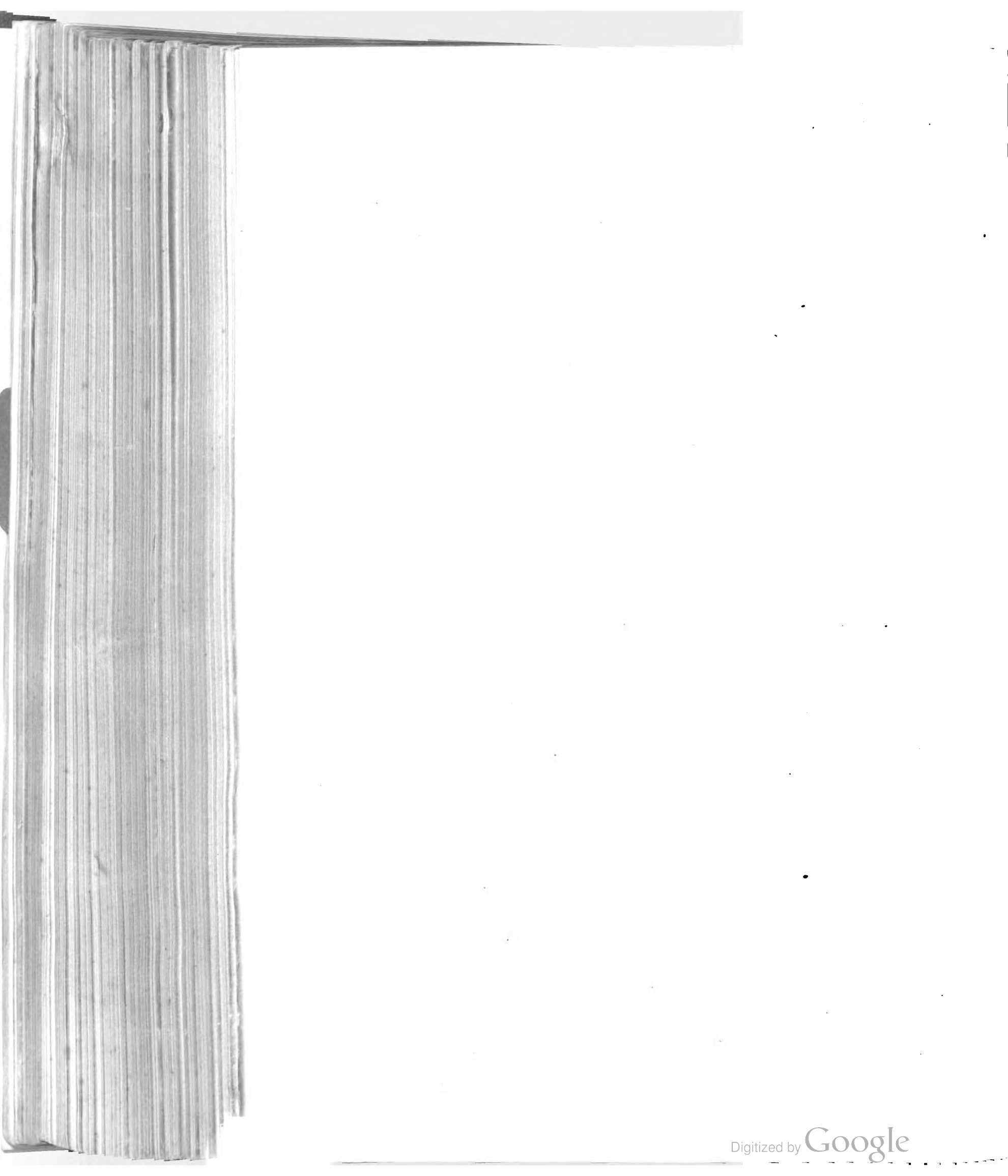
lie around them. They often do not know which direction from them the summit of the shoal lies and are afraid to move from the position which thick weather and darkness finds them in.

Mr. C. H. Farley, chairman of the harbor commission of Portland (writing unofficially, it should be said), mentions that "the Dart was the largest privateer of the war of 1812. She sailed from this port and was lost on George's. The brother of the captain was a prominent merchant of Portland, and ever after that disaster, as long as he lived, advocated the building of a monument on that shoal. The bones of all who have perished there would make a monument higher than that on Bunker Hill; and the property lost would pay for one of silver, if not too high."

My proposition, less equivocal than that of the privateersman's brother, is, that to our brothers, the fishermen and peaceful traders who have died for us on George's Shoal, let us raise a monument in the form of a light-house and furnish it with a fog-horn to utter one perpetual wail.

HENRY MITCHELL,  
*Coast and Geodetic Survey.*





## APPENDIX No. 12.

COMPARISON OF TRANSVERSE SECTIONS IN THE DELAWARE RIVER, BETWEEN OLD NAVY-YARD  
AND EAST END OF PETTY'S ISLAND, FOR THE YEARS 1819, 1843, AND 1878.

By HENRY L. MARINDIN, Assistant.

UNITED STATES COAST AND GEODETIC SURVEY,  
*Boston, Mass., March 30, 1885.*

DEAR SIR: I have prepared and desire to submit herewith a report on Transverse Sections in the Delaware River, between Old Navy-Yard and East End of Petty's Island, compared for the years 1819, 1843, and 1878.

The following comparison of the changes in the transverse section of this part of the Delaware River was undertaken because it embraces the principal part of the harbor of Philadelphia, and although comparisons have been made before by giving the shift of the river bed by volumes, no showing has been made by means of profile of cross-section. The importance of this part of the river may be inferred from the fact that it covers both of the Windmill Island channels, also Smith's Island Bar, and both of the channels around Petty's Island. The selection of the transverse sections was determined by the position of the sounding lines of the survey made by McClure in 1819. These sounding lines were run, in most cases, so as to give a fair cross-section of the stream, although not at equal distances apart.

The changes are represented on the accompanying six plates, which explain themselves in a great measure. Some of the notable changes I will call your attention to briefly.

From Section 1, off Old Navy-Yard, to the present southern extremity of Windmill Island, the cross-sections reaffirm the discovery, in a preceding comparison of depths, of the increase of depth on the shoal ground south of Windmill Island. The wharf line indicates a general advance into the stream, with a corresponding deepening in the channel and an easterly movement of the westerly slope of the shoal, with an exception at Section 3, where this slope has remained stationary for the three epochs. Here at Section 3, off Pier 36, it would seem that the compensation for the advance of the wharf line was obtained wholly by the disappearance of the apron shown as existing in 1819 on the city front (see Section 3). Another feature of this cross-section is the disappearance of the dry-ground end of Windmill Island, already alluded to in another report.

From cross-section 4 to 9 we have the comparison of both of the Windmill Island channels. We may continue to notice the advance of the wharf-line, more marked however, between the years 1843 and 1878. This advance has in most cases been followed by an increase of channel depth, which is an improvement only where the depth is insufficient; but here the depth exceeds the wants of commerce, so that a questionable improvement was obtained at the expense of width of water-way where navigable room was already restricted. The depth along the island front has remained without change.

In the eastern channel the marked advance of the Jersey shore, by its occupation by wharves, has also been followed by increase of channel depth.

From Section 9 to 12 we have cross-sections over Smith's Island Bar. The advance of the wharves on the Philadelphia front is still maintained. A great importance attaches to this part of the harbor from the fact brought out by the resurvey made by the United States Engineer Depart-

ment, under Colonel Ludlow, in 1882, that the bar was shifting at an alarming rate, in one case 300 feet since the survey of 1878. The bar off the foot of Callowhill street (shown in cross-section 12) indicated by the resurvey, the examination of cross-sections 11, 12, and 13, shows a tendency, that of a retreat of the western slope of the Bar toward the Philadelphia shore. The Bar was either followed or preceded by the advance of the wharf.

At Section 9, off the foot of Market street, and at Section 10, an increase of channel depth following the advance of the wharf line along the frontage south of Market street; the easterly shift of Smith's Island Bar is probably the effect of the advance of the wharf line. Hence to be drawn from the inspection of the changes shown in the sections is that Smith's Island Bar is shifting, but more especially above Elbow at Cooper's Point.

Cross-sections 13, 14, and 15 show the changes at the Elbow. The movement on the channel by the building out of the wharves is still going on. The area in this bend was not affected to such a degree as the part of the channel.

The remaining cross-sections from No. 16 to 21 give the changes at the Island, and those from No. 22 to 29 show the same for the south side. I had intended to deduce from these sections the comparative values at different dates of the surveys, but will have to postpone this inquiry of time.

Trusting that these plats may be of use in the future studies and improvements for this part of the Delaware, I respectfully submit.

Very respectfully,

H  
Assista

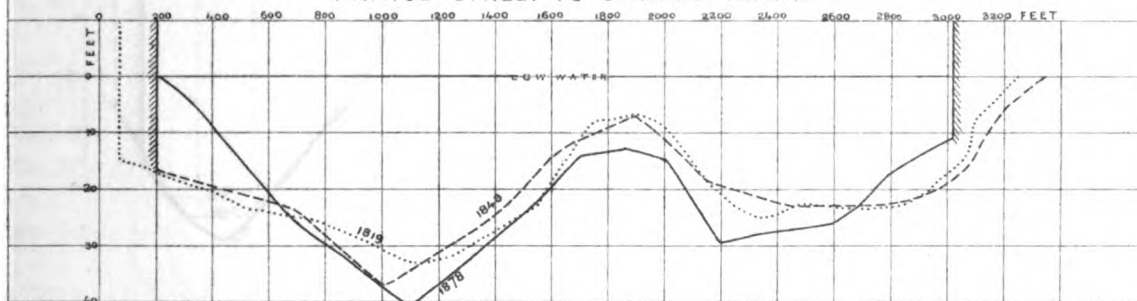
Prof. J. E. HILGARD,  
*Superintendent Coast and Geodetic Survey.*

## DELAWARE RIVER

TRANSVERSE SECTIONS COMPARED FOR THE YEARS  
1819-1843-1878

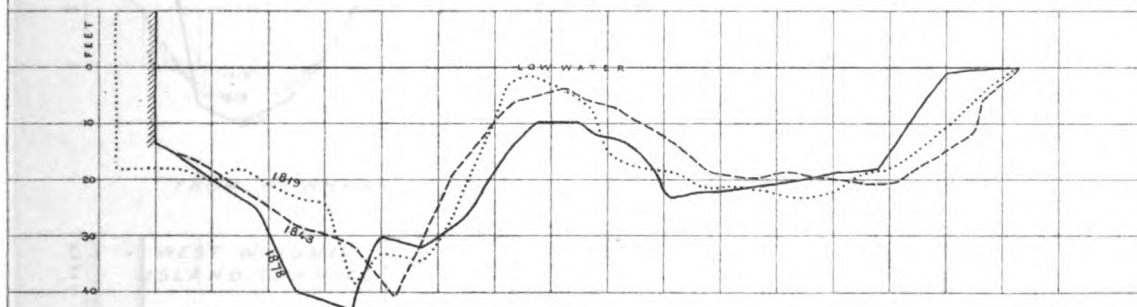
## SEC. 1

PRINCE STREET TO STARR'S WHARF



## SEC. 2

SIMPSON'S DRY DOCK TO AM. DREDGING CO'S LANDS

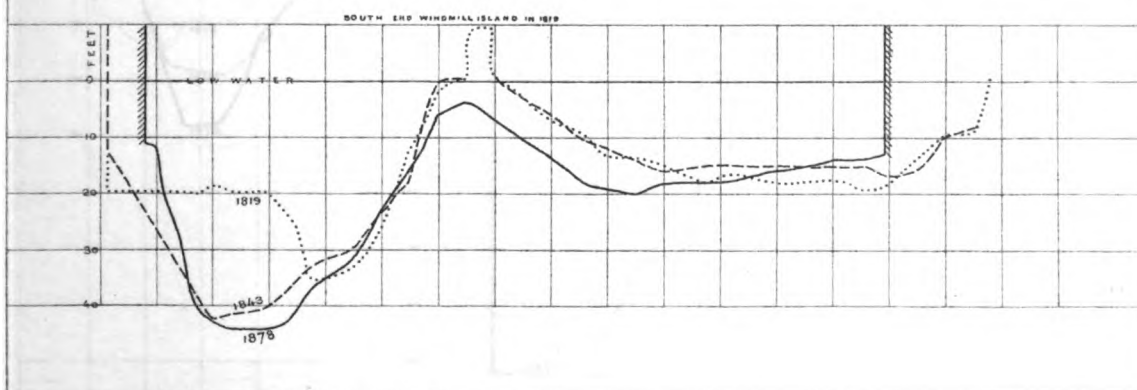


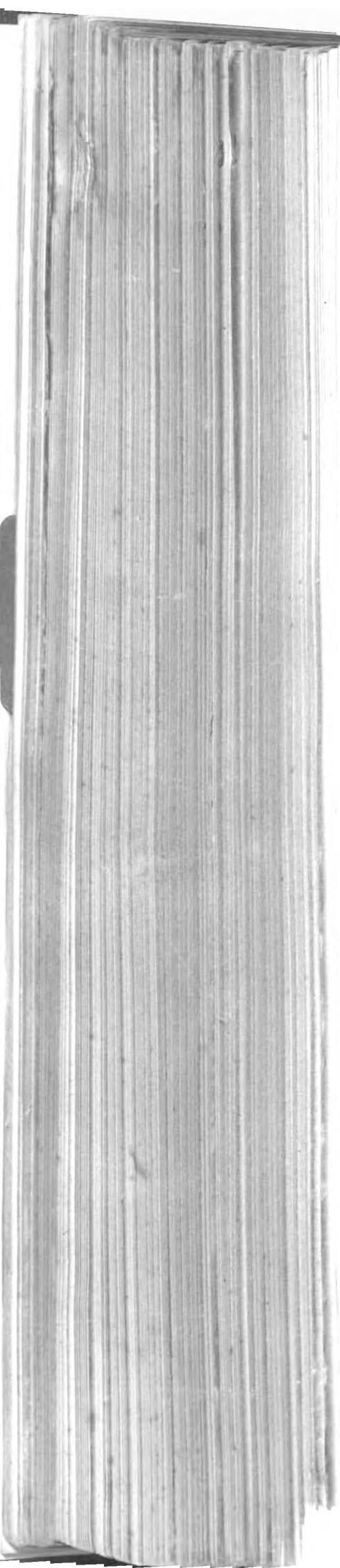
## SEC. 3

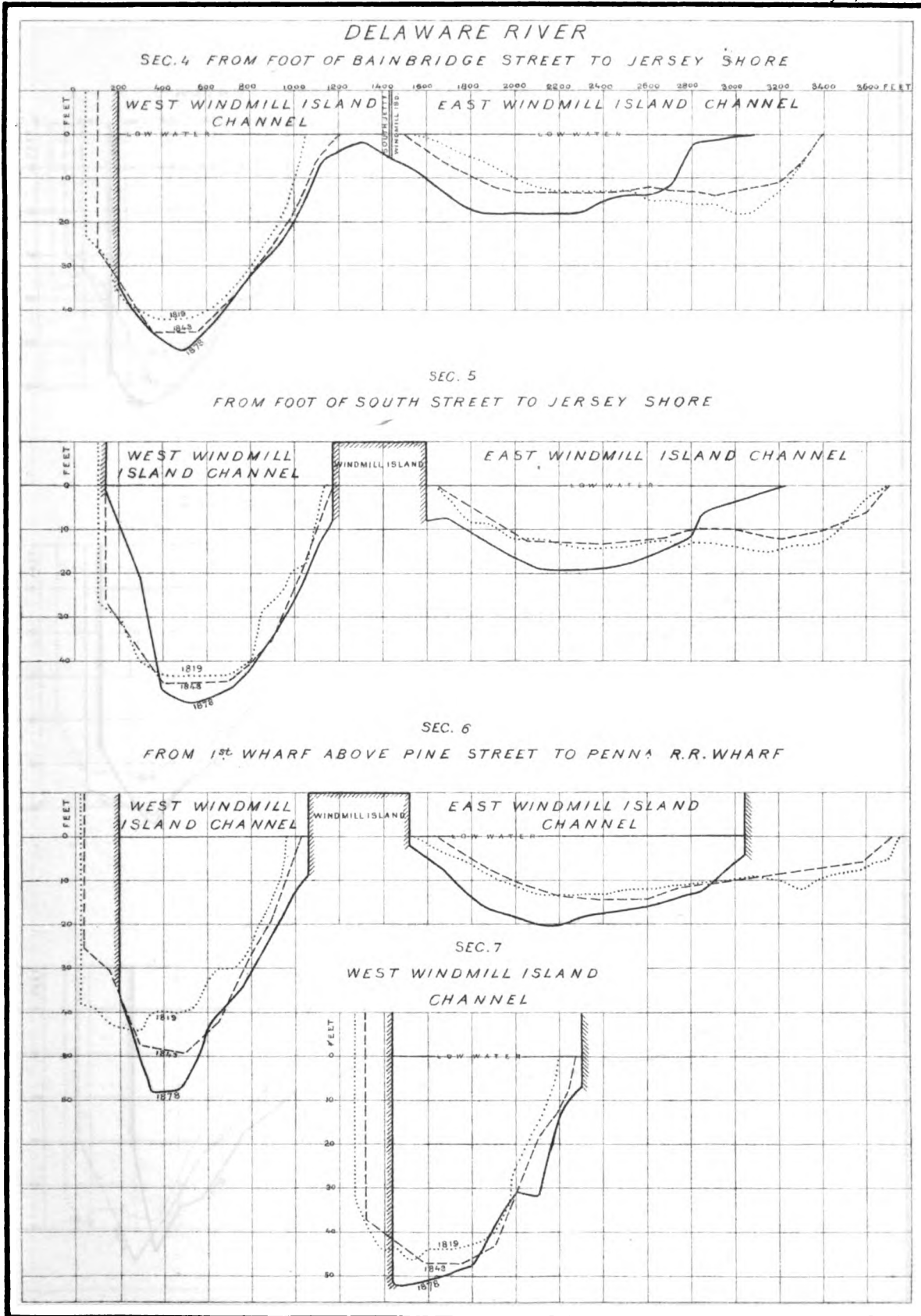
WEST WINDMILL ISLAND CHANNEL  
PIER 36 TO AM. DREDGING CO'S LANDS

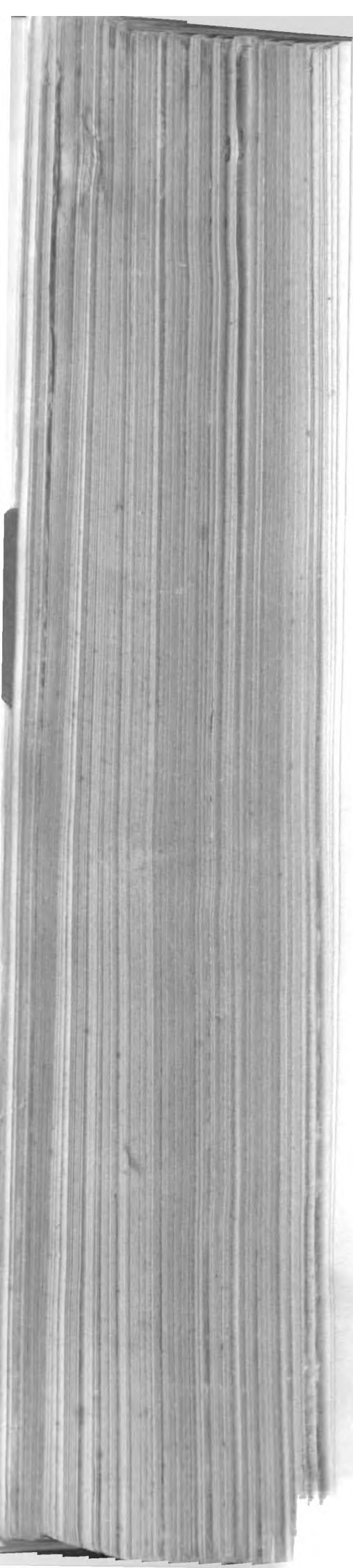
## SEC. 3

EAST WINDMILL ISLAND CHANNEL







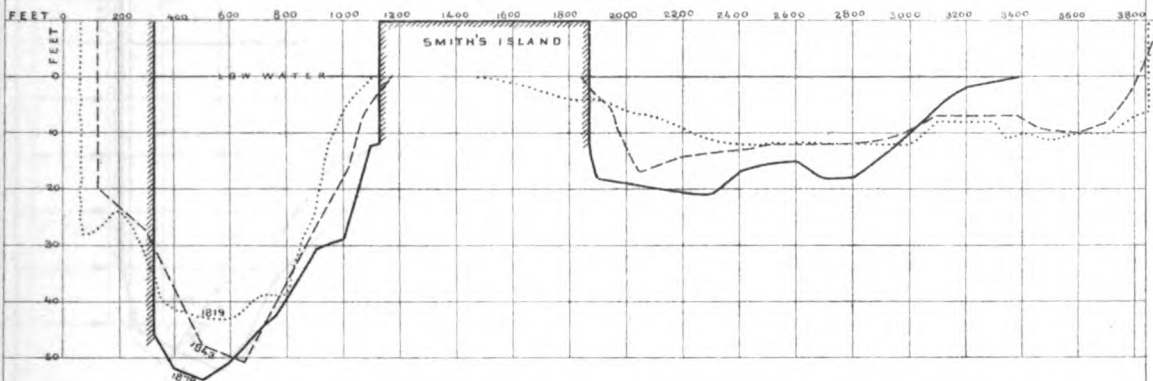




# DELAWARE RIVER

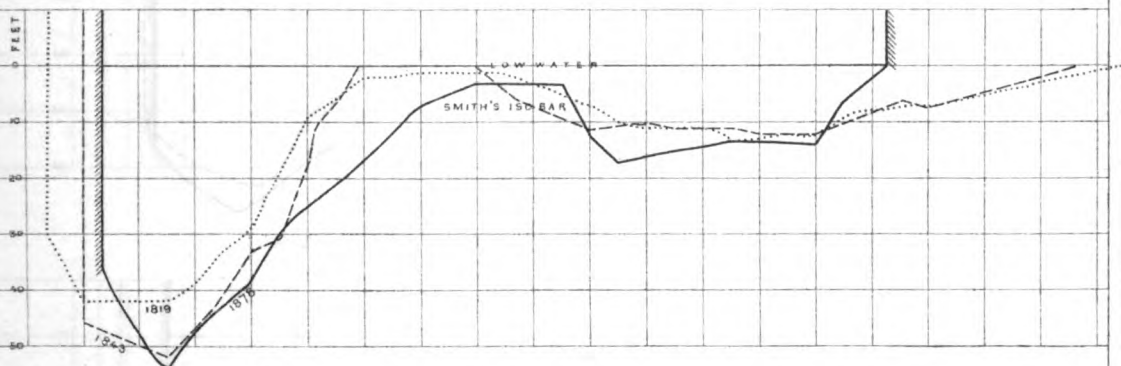
## SEC. 8

WALNUT STREET WHARF TO ARCH STREET, CAMDEN



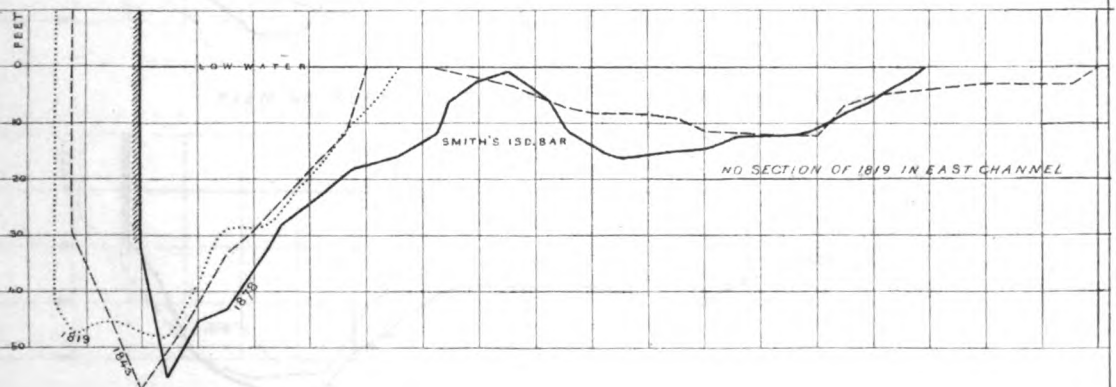
## SEC. 9

FOOT OF MARKET STREET TO KNICKERBOCKER ICE CO'S WHARF

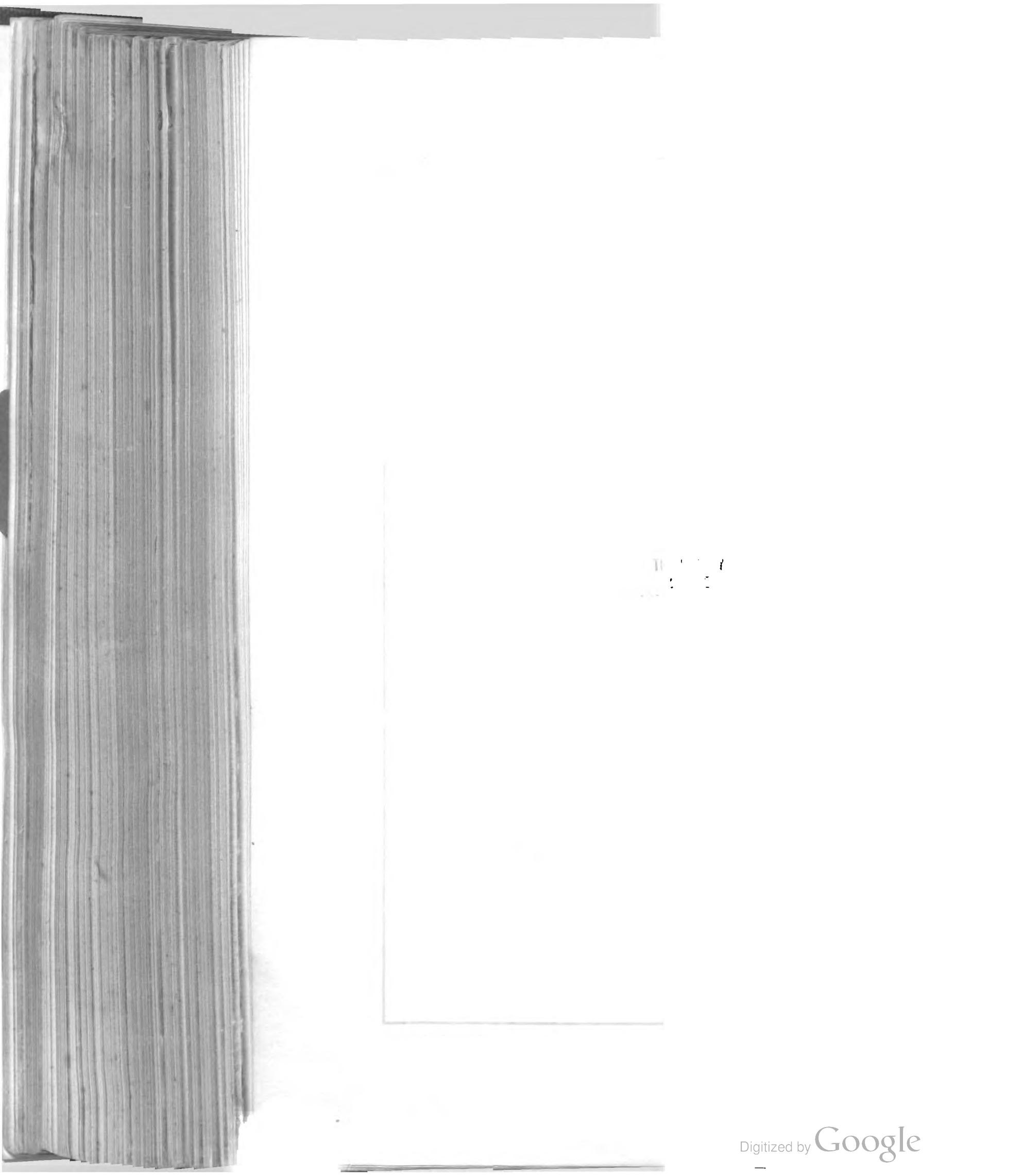


## SEC. 10

ARCH STREET WHARF TO JERSEY SHORE

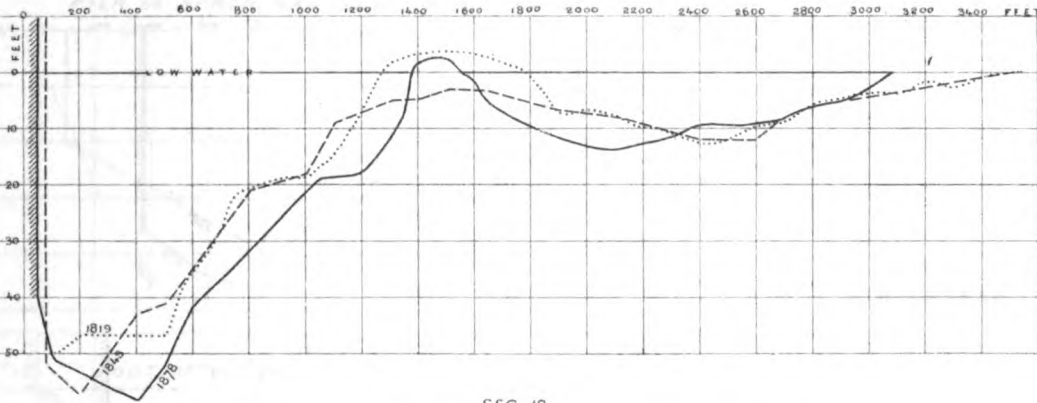






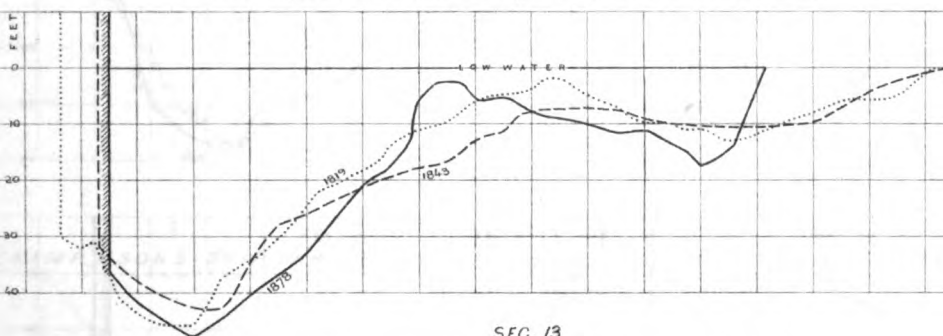
# DELAWARE RIVER

## SEC. II, PIER 10 RACE STREET TO ELM STREET CAMDEN



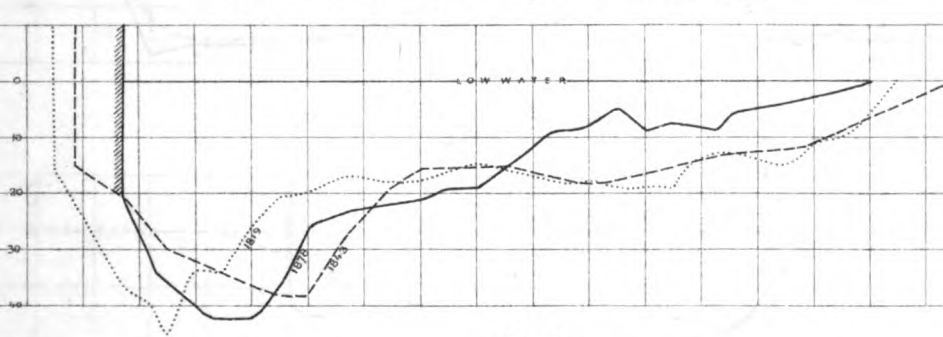
## SEC. 12

### PIER 21 (CALLOWHILL STR.) TO VINE STR. FERRY



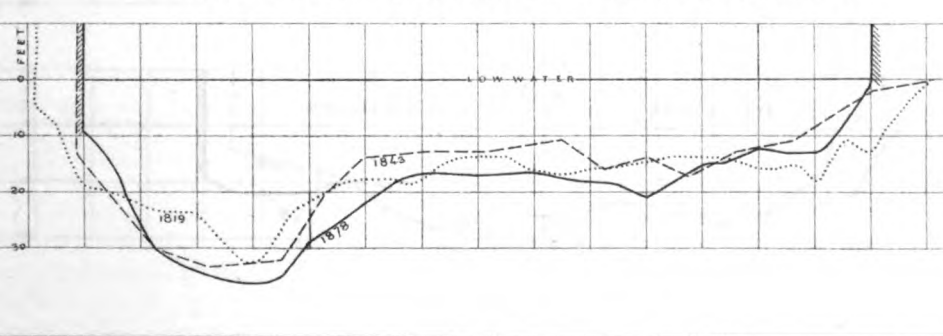
## SEC. 13

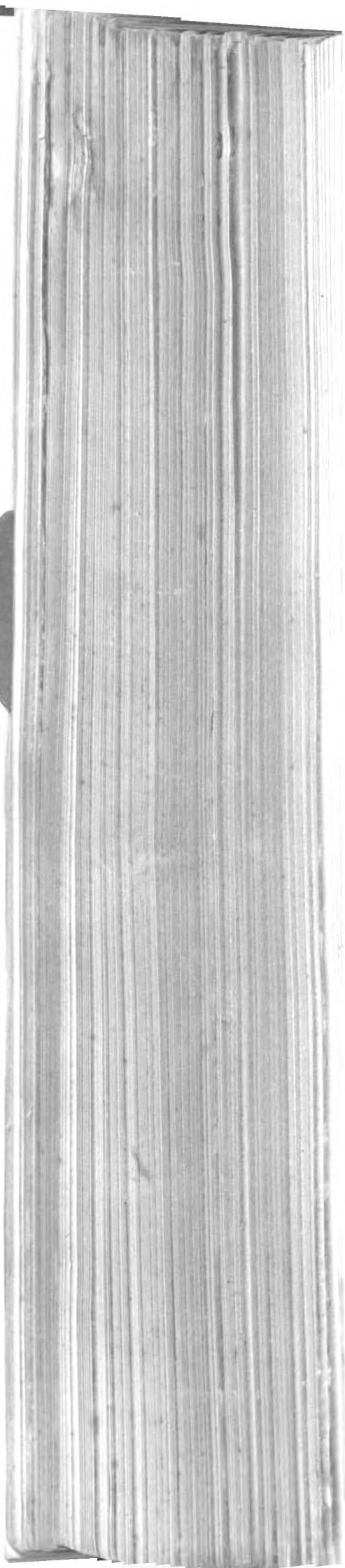
### PIER 35 (COHOCKSINK CR.) TO COOPERS POINT



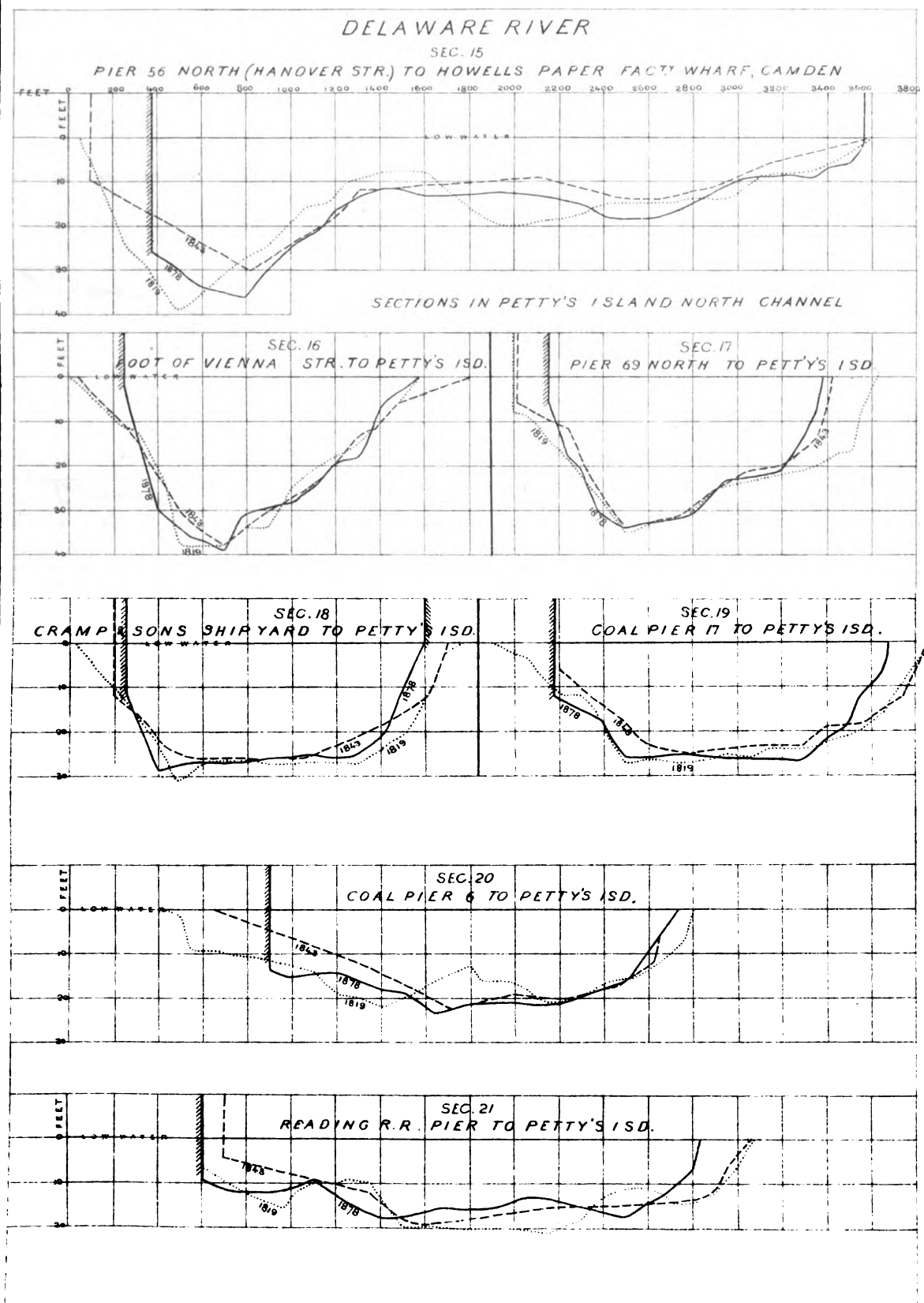
## SEC. 14

### PIER 46 NORTH TO SHACKAMAXON FERRY SLIP, CAMDEN



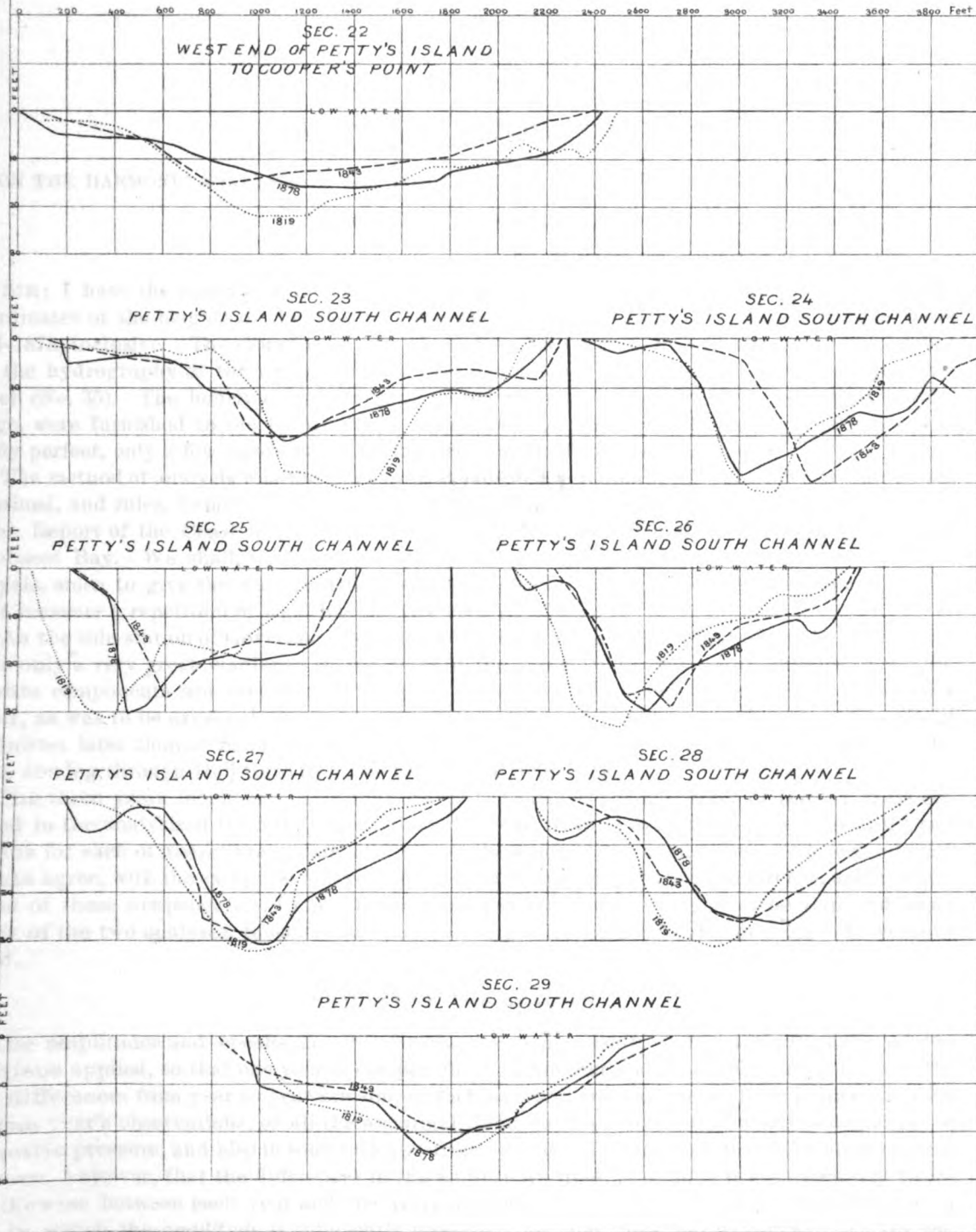


111





# DELAWARE RIVER SECTIONS IN PETTY'S ISLAND SOUTH CHANNEL





## APPENDIX No. 13.

ON THE HARMONIC ANALYSIS OF THE TIDES AT GOVERNOR'S ISLAND, NEW YORK HARBOR.

By WILLIAM FERREL.

WASHINGTON, D. C., *June 30, 1884.*

SIR: I have the honor to submit the following report on the harmonic analysis of the hourly co-ordinates of the heights of the tides at Governor's Island, in New York Harbor, for the years 1876-1878, inclusive. The situation of the tide-station with regard to the entrance to the harbor and the hydrography of the vicinity can be best understood by a reference to the accompanying sketch (No. 35). The hourly co-ordinates, measured from the curves of the self-registering tide-gauge, were furnished to me by Mr. R. S. Avery, chief of the Tidal Division. The series was nearly perfect, only a few co-ordinates having been supplied by interpolation.

The method of analysis was the same as that followed heretofore, the principles of which were explained, and rules, formulæ, and examples of the various reductions given, in Appendix No. 11 of the Report of the Coast and Geodetic Survey for 1878, in which were discussed the tides of Penobscot Bay. We shall, therefore, present here, for the most part, the results merely of the analysis, since to give the work in detail, with examples of the various reductions, would be in a great measure a repetition of what has already been published.

As the tide-station of Governor's Island is only about 20 miles from that of Sandy Hook, there is not only a very great similarity in the tides of the two stations, but the amplitudes of all the separate components are very nearly the same for both. The epochs, however, at Governor's Island, as was to be expected, are somewhat greater, being such as to cause the tides to be about 29 minutes later than at Sandy Hook. The tides, therefore, do not seem to be much affected by waves coming through Hell-Gate from the tides in the Sound above.

The three years included in this analysis are the same as the first three of the six years embraced in the analysis of the Sandy Hook tides. It is interesting to compare the results at the two stations for each of these three years, and observe how nearly the amplitudes of the several components agree, with the exception of a very small regular and proportionate difference, and also the epochs of these components. To facilitate the comparison of the averages of the amplitudes and epochs of the two analyses, those of Sandy Hook are given here by the side of those of Governor's Island.

### RESULTS OF THE ANALYSIS.

The amplitudes and epochs, as given in the following results of the analysis, have all the reductions applied, so that one year is comparable with another and with the mean of all, and the small differences from year to year are simply such as result from an incomplete elimination, with only one year's observations, of all the abnormal disturbances arising from winds and changes of barometric pressure, and also in some measure from unavoidable imperfections of the observations. It is seen, however, that the differences in the amplitudes from year to year are extremely small, and likewise between each year and the average of all. The epochs also agree very well in all cases in which the amplitude is sufficiently large to determine them, but of course when the amplitudes are very small there are great uncertainties in the values of the epochs as brought out in the analysis, and a nice agreement cannot be expected.



## M TIDE.

	1876.	1877.	1878.	Mean.
$A_1 =$	0.023	0.027	0.035	0.028
$e_1 =$	125°	16°	348°	----
$A_2 =$	2.153	2.147	2.152	2.149
$e_2 =$	231° 8	230° 5	230° 6	231° 0
$A_3 =$	0.023	0.029	0.018	0.023
$e_3 =$	210°	206°	189°	202°
$A_4 =$	0.084	0.075	0.086	0.082
$e_4 =$	334°	329°	328°	330°
$A_6 =$	0.066	0.066	0.071	0.068
$e_6 =$	90°	85°	82°	86°

## S TIDE.

$A_1 =$	0.033	0.045	0.050	0.042
$e_1 =$	242°	223°	238°	234°
$A_2 =$	0.408	0.416	0.427	0.417
$e_2 =$	254° 7	256° 2	260° 5	257° 1
$A_3 =$	0.045	0.037	0.043	0.042
$e_3 =$	99°	87°	87°	91°
$A_4 =$	0.036	0.051	0.036	0.041
$e_4 =$	71°	61°	80°	70°

## K TIDE.

$A_1 =$	0.317	0.322	0.322	0.320
$e_1 =$	105° 5	106° 3	106° 0	105° 9
$A_2 =$	0.129	0.118	0.114	0.120
$e_2 =$	66° 8	51° 8	37° 0	51° 9

## O TIDE.

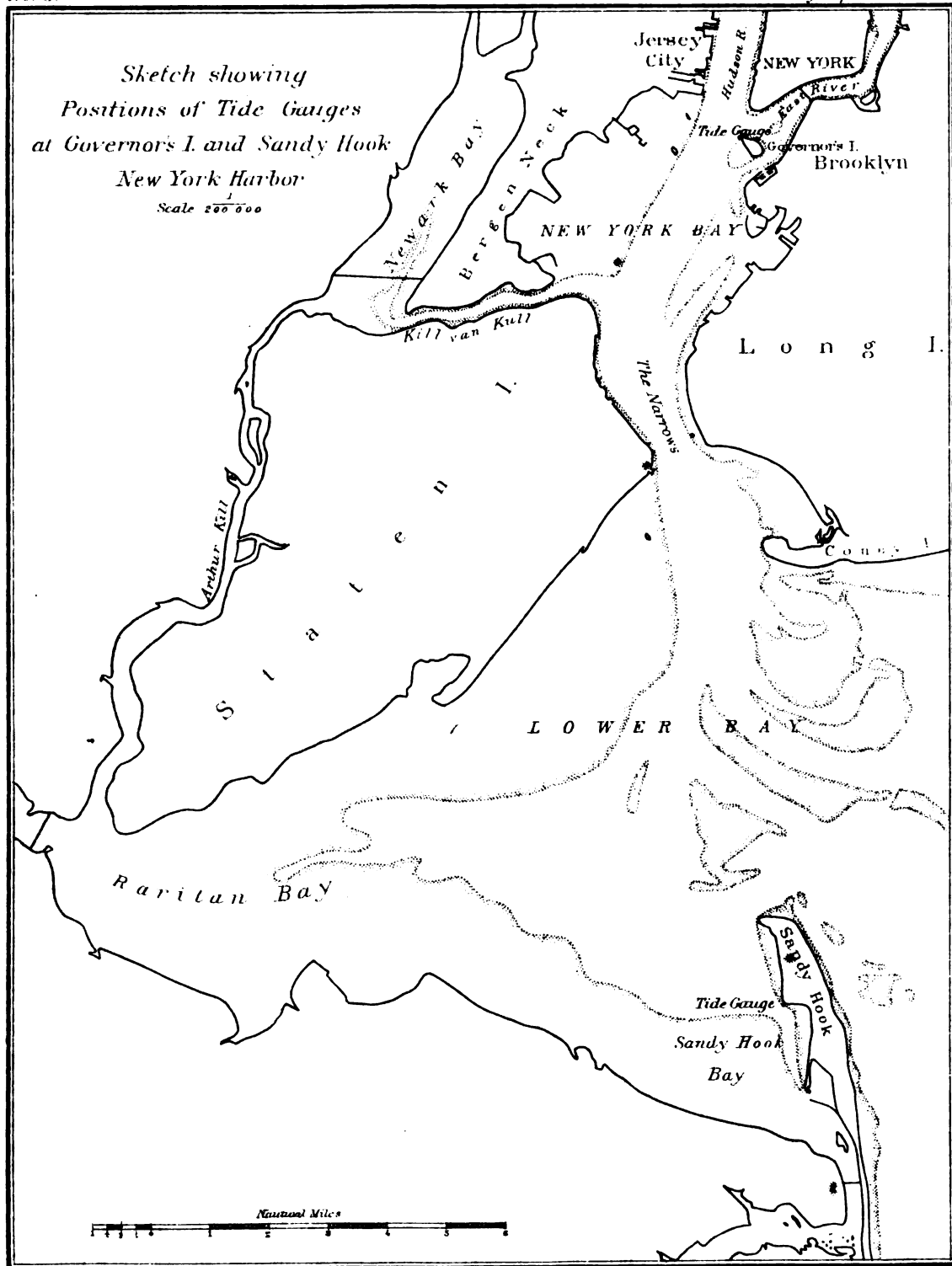
$A_1 =$	0.163	0.150	0.156	0.156
$e_1 =$	108° 8	99° 6	101° 1	103° 2

## P TIDE.

$A_1 =$	0.107	0.115	0.093	0.105
$e_1 =$	102° 9	105° 6	103° 9	104° 1

## L TIDE.

$A_2 =$	0.100	0.114	0.096	0.103
$e_2 =$	64°	67°	52°	61°





*Analysis—Continued.*

## N TIDE.

	1876.	1877.	1878.	Mean.	Sandy Hook.
$A_1 =$	0.461	0.482	0.497	0.480	0.490
$\epsilon_1 =$	210°.7	206°.5	210°.8	209°.3	198°.7

 $\nu$  TIDE.

$A_2 =$	---	---	0.155	---	0.105
$\epsilon_2 =$	---	---	203°	---	198°

## HEIGHT OF MEAN LEVEL.

$A_0 =$	4.536	4.665	4.796	4.666	---
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It was not thought worth while to extend the analysis to several other smaller components of which the amplitudes are less than one inch in the Sandy Hook tides, since, on account of the near agreement of those above, mostly with the amplitudes and epochs of the Sandy Hook tides, there could be no sensible difference in these smaller components.

If we take the amplitudes and epochs of the four principal semi-diurnal components and likewise of the three diurnal components, for both Governor's Island and Sandy Hook, we have the following relations between them :

*Semi-diurnal components.*

	$M_2$		$S_2$		$K_2$		$N_2$	
	A	$\epsilon$	A	$\epsilon$	A	$\epsilon$	A	$\epsilon$
Governor's Island.	2.149	231.0	0.417	257.1	0.120	51.9	0.480	209.3
Sandy Hook.	2.246	217.0	0.455	245.9	0.129	37.4	0.490	198.7
Difference.	0.097	14.0	0.038	11.2	0.009	14.5	0.010	10.6

*Diurnal components.*

	$K_1$		$O_1$		$P_1$	
	A	$\epsilon$	A	$\epsilon$	A	$\epsilon$
Governor's Island.	0.320	105.9	0.156	103.2	0.105	104.1
Sandy Hook.	0.334	90.1	0.170	96.5	0.103	103.8
Difference.	0.014	15.8	0.014	6.7	0.002	0.3

If to the amplitudes of Governor's Island we add one-twentieth part we get those of Sandy Hook, in both the diurnal and semi-diurnal components, within one-fifth of an inch, and much less, except in the case of the semi-diurnal solar component, and the greatest difference without this reduction, which is in the case of the mean semi-diurnal lunar component, is only 0.097 of a foot.

In the epochs the difference is  $14^\circ$  for the mean lunar semi-diurnal component, which should have much the greatest weight in the determination on account of its comparatively large amplitude, but the average of all is  $12^\circ.6$ . In the principal diurnal component it is  $15^\circ.8$ , though in the two other very small components, with amplitudes so small that the epochs cannot be accurately brought out in the analysis, they are much less. Putting, therefore, the general difference of the epochs for both diurnal and semi-diurnal components at  $14^\circ$ , as given by the principal semi-diurnal component, this gives 28 lunar or about 29 solar minutes for the time that the tide occurs at Governor's Island after the time of the tide at Sandy Hook. Considering the small difference in the amplitudes of the components of the two stations, this is the only correction required to reduce the tide-predictions of Sandy Hook to those of Governor's Island with sufficient accuracy for any practical purposes; but if thought desirable the height of the tide above or below mean level can be diminished one-twentieth, a correction which would amount on the average to one-tenth of a foot.

These results, therefore, show that it will be unnecessary to make separate tide-predictions by means of the machine, or otherwise, for both Sandy Hook and Governor's Island, but that the latter may be obtained from the former with sufficient accuracy by simply adding 29 minutes to the times.

The heights of mean level,  $A_0$ , above the zero of the tide-gauge, indicate that this zero changed its level at the rate of 0.26 feet, or about 3 inches, in two years, as there seems to be a gradual increase in the values of  $A_0$  for the several years.

#### DETERMINATION OF GENERAL CONSTANTS.

In the tidal theory there are certain constants which have to be determined from observation for each tide-station, as explained in Appendix No. 11 of the Report of the Coast and Geodetic Survey for 1878. From the theoretical relations of the three principal diurnal components given in section 31 of that Appendix we get from the results of the analysis for Governor's Island the following three equations:

$$\begin{aligned} 0.320 - 0.6 \delta\mu &= (.5306 - 13.1 \delta\mu) (1 + .230 E) A_0 \\ .157 &= .3813 (1 - .230 E) A_0 \\ .105 &= (.1730 - 13.6 \delta\mu) (1 + .196 E) A_0 \end{aligned}$$

The solution of these equations gives

$$\delta\mu = -.0005 \qquad A_0 = 0.505 \qquad E = 0.788$$

In making out the preceding conditions it was assumed that the moon's mass  $\mu$  is equal 0.0125 of the earth's mass. The preceding conditions give a correction for this assumed mass of  $\delta\mu = -.0005$ . With this correction we get

$$\mu = 0.0125 - .0005 = 0.012 = \frac{1}{83}$$

for the moon's mass. This, we have reason to think, is about its true mass, but the result must be regarded as being in some measure accidental, for the amplitudes of the diurnal tide are too small in the Atlantic Ocean to obtain an accurate determination of the moon's mass; and, besides, these relations are generally disturbed by shallow-water components of the same period, where there are sensible components of this sort, as there are, except in very deep water.

From the relations of the first two equations in section 32 of the Appendix referred to above, we get with the epochs of  $K_1$  and  $O_1$  in the preceding results

$$\begin{aligned} 105^\circ.9 &= L_0 + 13^\circ.18 G \\ 103^\circ.2 &= L_0 - 13^\circ.18 G \end{aligned}$$

From these we get  $L_0=104^\circ.5$  and  $G=0.1$ . From the first of these we get

$$\frac{104^\circ.5}{14^\circ.492}=7 \text{ hours nearly}$$

for the mean time by which the diurnal tide follows the upper transit of the mean moon. The value of  $G$ , above, indicates that the maximum of the diurnal tide follows the maximum of the forces by 0.1 of a day.

From the relations of section 33 in the Appendix, referred to above, we get, with the amplitudes of these components in the preceding results,

$$\begin{aligned}.1931 \ c &= (.4852 - 36.2) (1 + .425 \ E) \\ .0573 \ c &= (.1256 - 3.2 \ \delta\mu) (1 + .460 \ E) \\ .2218 \ c &= .1922 (1 - .228 \ E)\end{aligned}$$

The solution of these equations gives

$$\delta\mu = .0025 \qquad c = 1.0750 \qquad E = -1.117$$

The first of these, as a correction for the moon's mass, gives

$$\mu = 0.0125 + .0025 = 0.015 = \frac{1}{67}$$

for the moon's mass. The preceding conditions, which are essentially those used by Laplace, have always given a mass too large, the mass obtained by Laplace being about  $\frac{1}{7}$ . But the declination inequality which enters into these conditions is only 1.5 inches in amplitude, and hence it is too small to base a reliable determination upon it.

The constant  $c$  being greater, as usual, than unity, indicates that the amplitudes of the smaller component, in being superimposed upon the mean and principal lunar component, are decreased about one-thirteenth, from the effect of friction being as a power greater than the first power of the velocity.

From the relations of the first two equations of section 34 of the same Appendix, we get

$$\begin{aligned}231^\circ.0 &= L_0 \\ 257^\circ.1 &= L_0 + 24^\circ.4 \ G.\end{aligned}$$

With the value of  $L_0$  in the first equation, we get from the second  $G = 1.07$ , which indicates that the maximum of the semi-diurnal tides follows the maximum of the forces by 1.07 of a day.

With the value of  $L_0$ , we get

$$\frac{231^\circ.0}{28^\circ.984} = 7.97 \text{ hours} = 7^h 59^m$$

as the time by which the high-water of the lunar semi-diurnal component follows the transit of the mean moon over the meridian.

None of the preceding general constants differs much from those obtained in the same manner from the results of the analysis of Sandy Hook.

I have the honor to be, very respectfully, yours,

WILLIAM FERREL.

Prof. J. E. HILGARD,

*Superintendent Coast and Geodetic Survey.*



## APPENDIX No. 14.

### REPORT ON DEEP-SEA CURRENT WORK IN THE GULF STREAM.

By Lieut. J. E. PILLSBURY, U. S. N., Assistant.

#### LETTERS OF INSTRUCTION.

COAST AND GEODETIC SURVEY OFFICE,  
*Washington, January 27, 1885.*

SIR: As soon as the steamer Blake and the hydrographic party under your charge are ready, you will please proceed to the Straits of Florida and execute the following hydrographic work:

I. Run lines of soundings, &c., from the east coast of Florida and in the northwest Providence Channel, according to the scheme that will be furnished to you.

II. Obtain a series of observations for currents in the Gulf Stream between Cape Florida and Gun Cay, Bahama Banks, followed by a similar series between Cape San Antonio and Yucatan; this to be followed by other observations at the first station.

The latter observations need only be taken at part of the stations first occupied, but should be made at another phase of the moon, in order to study, as far as practicable, such tidal action as may exist.

You will endeavor to reach Hampton Roads before July 1.

The Hydrographic Inspector will furnish you with projections and other data requisite for the execution of the work.

Yours, respectfully,

J. E. HILGARD,  
*Superintendent.*

Lieut. J. E. PILLSBURY, U. S. N.,  
*Assistant Coast and Geodetic Survey,  
Commanding Steamer Blake, Navy-Yard, Washington D. C.*

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#### DETAILED INSTRUCTIONS.

COAST AND GEODETIC SURVEY OFFICE,  
*Washington, January 26, 1885.*

DEAR SIR: In carrying out the instructions of the Superintendent dated January 27, instant, you will be guided as far as possible by the following considerations: In running the lines of soundings on the Florida coast and in the northwest Providence Channel it is desirable to take serial temperatures in crossing the Gulf Stream, but in the event of bad weather coming on, necessitating an abandoning of any line, it is not advisable to expend much coal in the endeavor to execute this part of the work, as the primary object of the season will be to make complete current observations, and nothing should be allowed to hazard the success of that undertaking that can be foreseen.

In taking the current observations it is desired to obtain a complete series at five or seven sta-



tions across the Gulf Stream between Cape Florida and Gun Cay, Bahama Banks, of surface, fifty fathoms, and at some depth between that and the bottom, occupying each station twenty-four or more hours at points at which it is possible to anchor.

Between Cuba and Yucatan the depth of water will probably prevent anchoring in a part of the passage about sixty-five miles in width. On this part you will make at least one drifting observation, making three trials from the same point, with buoys for surface-currents and also for sub-currents at fifty or more fathoms depth.

One series in the Straits of Florida and one to the westward of Cuba are necessary, but it is very desirable also to make a second trial in the former, occupying one of the first stations at a different phase of the moon. In this second trial the weather will probably be more settled, and it is advisable to endeavor to make observations at one point for a long interval rather than to occupy more stations for shorter lengths of time.

Very respectfully,

C. M. CHESTER,

*Commander, U. S. N., and Hydrographic Inspector Coast and Geodetic Survey.*

Lieut. J. E. PILLSBURY, U. S. N.,

*Commanding Steamer Blake, Washington, D. C.*

#### REPORT.

U. S. COAST AND GEODETIC SURVEY,

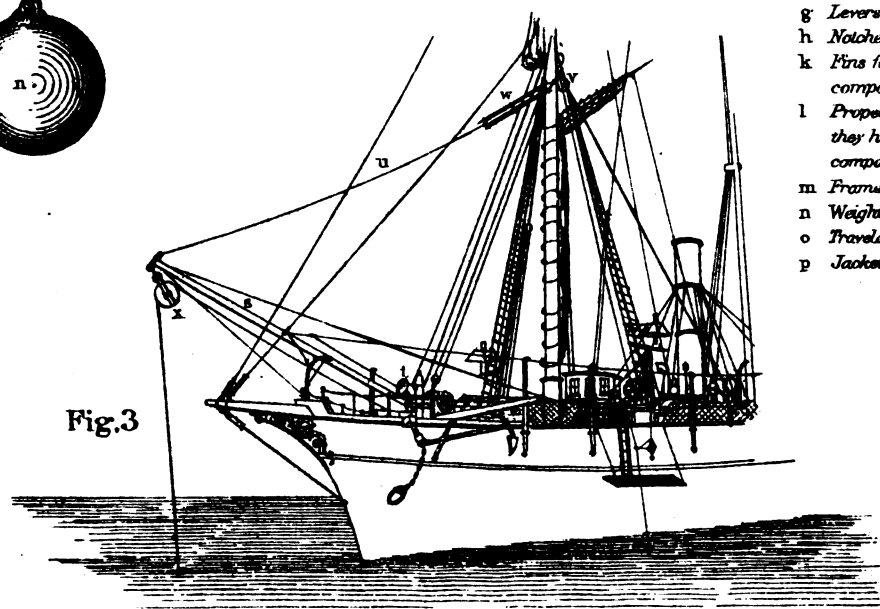
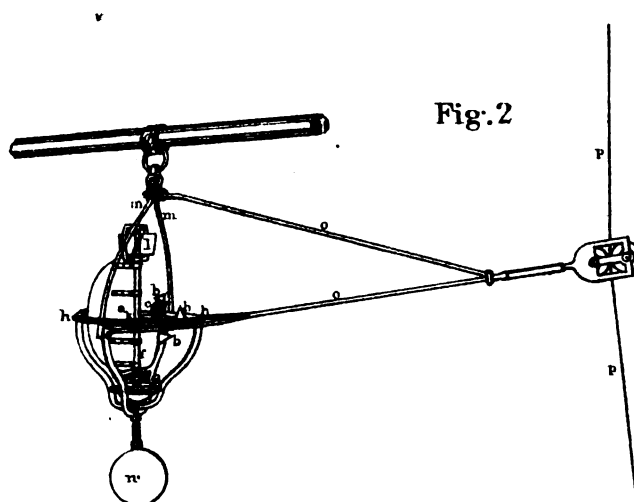
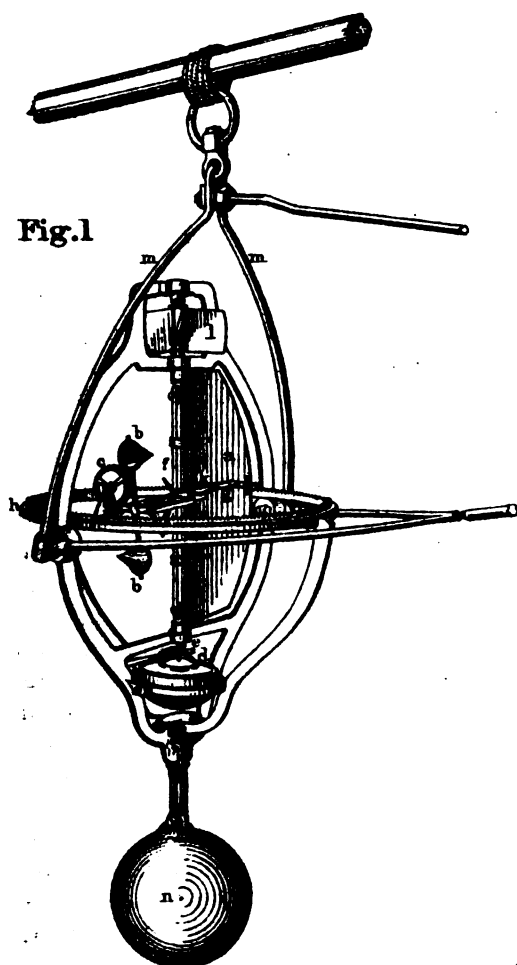
*Steamer Blake, October 5, 1885.*

SIR: I have the honor to make the following report of the season's work at Gulf Stream current observations, in obedience to the instructions of the Superintendent, dated January 27. As this is the first season in which the party under my charge has been engaged in observations of this character, and as I believe it is the first attempt by any party to use the methods which were used by us, and also because I think that the student of the results should have a full knowledge of the methods, I venture, even at the risk of submitting a rather voluminous report, to explain the instruments used to obtain the observations and the manner of using them.

The object of the cruise was to anchor in the deep water of the Gulf Stream, and to observe the currents from the vessel so anchored. The first thing therefore to do, was to devise a method of anchoring the vessel expeditiously, with certainty, and with safety to the vessel and appliances. The *Blake* was formerly fitted with dredging gear, and for the sake of economy all the parts of this apparatus which could be used were incorporated in the arrangements made for anchoring. Without stopping to explain the reasons for discarding various ideas which were presented for overcoming the enormous strains in anchoring, or to give the reasons why certain other ideas were adopted, I will at once give a description of the gear used. It was thought to be absolutely necessary to relieve the sudden strain (due to the motion of the vessel) on the anchoring cable. To do this a heavy spar or boom (*s*, illustration 36, fig. 3) was attached by a goose-neck to the pawl-bitt (*t*) in the bow. This boom was held up by a steel-wire rope or topping-lift (*u*) at an angle of about 45°. The topping-lift rove through a large block (*v*) at the masthead, and thence through another large block on the deck, the same distance abaft the mast that the end of the boom was forward of it. At the end of the lift abaft the block was attached an arrangement of rubber buffers about 8 feet long, into which was hooked a powerful purchase. It will be seen that upon any weight coming on the end of the boom the strain was transferred by straight thrust to the pawl-bitt, a straight thrust downward on the mast, and a pull forward on the rubber buffers compressing them.

This arrangement worked admirably with great strains, but the pitching of the vessel, causing the wire-rope topping-lift to continually move the sheaves of the two blocks over which it rove, necessitated a change. The rubber accumulator (*w*) was then placed between the boom and the topping-lift, and no trouble was afterward experienced. The anchoring line at first used, or rather tried, was the old dredge-rope of galvanized steel wire. This was a little more than  $\frac{3}{8}$  inch

APPARATUS DEvised BY LIEUT. J. E. PILLSBURY, U. S. N. ASSIST.  
FOR OBSERVATIONS OF DEEP-SEA CURRENTS



- a Rudder
- b Speed indicator
- c Register
- d Compass bowl
- e For locking compass needle
- f Metal stem connecting k and e
- g Levers for locking rudder in h
- h Notched ring
- k Pins for locking rudder and compass needle
- l Propeller for securing fins after they have locked rudder, and compass
- m Frame supporting Meter by trunnions
- n Weight
- o Traveler
- p Jockey



in diameter, but it was soon discarded as being altogether too weak, and another one of  $\frac{3}{4}$  and  $\frac{5}{8}$  inch diameter used. This line was carried on the old dredge-reel, and led from it to the main reeling engine, and thence through a large leading block (*x*) at the outer end of the boom. The leading blocks were of very heavy make, with sheaves nearly 2 feet in diameter. During the cruise four of the straps of these blocks showed signs of giving way, but the weakness was discovered in time, so that no accident happened.

The operation of anchoring was as follows: The anchor (about 700 pounds in weight) was hung by the anchoring-rope from the end of the boom; at the signal, the men at the reel-brake and reeling-engine brake eased them slightly and allowed the rope to pay out, keeping as nearly as possible an even speed of about 60 or 70 fathoms per minute. Upon the anchor touching the bottom, if it was not paying out faster than this, the rope would stop running, and the register being read, the depth was known. The rope was then paid out slowly, the anchor dragging along the bottom and the ship drifting. If the anchor nipped, the boom would immediately come down more or less, depending upon the current, and the rubber buffers would compress. After a certain scope was out, generally about twice the depth, the rope was secured by a screw clamp, so as to relieve the strain on the reeling-engine and reel. We found that in heaving in we could always tell when the anchor ceased to hold on the bottom by the jumping of the boom. With 800 or more fathoms of rope out, the time of heaving in and securing the anchor was generally less than 45 minutes, including getting in the jackstay (which will be explained further on), the ship's engines being used to steam ahead, so as to ease the strain. With but little current the reeling-engine could heave in the anchoring-rope more than 50 fathoms per minute.

The instrument devised by me to obtain the strength and direction of the currents at any depth consists of a freely-moving rudder of thin metal (*a*). (See illustration 36, figures 1 and 2.) On the front of this, and attached to the rudder, is a set of four metal cones (*b*), placed at the extremities of two arms or spokes which are at right angles to each other. The cones are attached to the arms in such a way that the center of the base of each is equidistant from the center of the spokes, and the apices of all point in the same direction with reference to the spokes, so that when in the current the base of the cone above the axis is towards the current and the apex of the cone diametrically opposite. At the axis of the system is a small shaft turning in points, and by a worm on it turning as it revolves differential wheels (*c*) which register revolutions.

Below the rudder is a compass bowl (*d*) and needle hung in gimbals, and a device (*e*) by which the needle can be lifted and clamped at any time. The rod performing this (*f*) runs through the stem on which the rudder swings, and attached to the same rod a system of levers (*g*), fast to the rudder, clamps its motion in a notched ring (*h*) surrounding the rudder at its middle. Attached to the levers are two horizontal wings or fins (*k*), so arranged that when the instrument is moving upward through the water the pressure of the water on them will clamp the rudder in the notched ring and will lift the compass needle, thus fixing the angle between the rudder and needle, and it remains fixed as long as the instrument has an upward motion. Above the rudder is a small propeller (*l*), arranged in such a way that it will give downward motion to its shaft when the meter has upward motion. The shaft moves through the center of the rudder shaft, and communicates by a small stem to the fins and levers described. The office of this propeller is to lock the fins after they have already clamped the needle and rudder. The whole arrangement worked well, the propeller locking when pulled through a space of 15 fathoms at good speed. The working parts of the meter are inclosed in a strong metal frame, which is hung in trunnions or gimbals (*m*), so that by attaching a weight at its lower end (*n*) it remained in a vertical position.

A value for the divisions on the register or the number of revolutions of the speed indicator per knot could be obtained only by comparisons with the log, and every opportunity was taken to make the comparison. A 21-foot pole was used instead of a log chip, and the meter was lowered to  $3\frac{1}{2}$  fathoms. Some of the register readings with currents of about half a knot as shown by the pole were about 100 turns less than with a stronger current, but it was thought that this discrepancy was due to error of pole rather than error of meter, and therefore an average of all was accepted. When it is remembered that 100 turns of the speed indicator in any case are less than one-tenth of a knot, the error of the mean, it will be seen, can be but little. The meter as at first made had a small wing attached to the rudder, which was intended to hold the speed indicator

from turning as it was lowered, and another device on the propeller stem for stopping it when the propeller was screwed down in hoisting. The fear of uncertainty of action of the former led to its abandonment, and with the latter the speed of hoisting caused such a variation in the amount of water through which it should be pulled to lock that I was led to discard it also, and to depend altogether on a correction to be applied.

The speed indicator turning a given number of revolutions when passing through a given distance in water, the correction due to hoisting and lowering could be known, and also knowing the speed of the intervening currents between the surface and the point of lowering and the time, the speed of the average current was taken as the one causing the error. The two forces turning the speed indicator were, the upward flow of the water in lowering a given distance and the downward flow in hoisting the same, and the mean horizontal flow from the time of touching the water to the time of stopping, and from the time of starting to hoist until the meter was out of water.

These forces were given a value in terms of revolutions, one being the base of the triangle and the other the perpendicular, and from Bowditch table II the hypotenuse taken. For example, the meter being lowered to 15 fathoms in a mean current of two knots, the time of lowering being 20 seconds and the time of hoisting 25 seconds, the number of revolutions in 45 seconds in a two-knot current would be 26; the number caused by lowering and hoisting through 15 fathoms would be 30. From Bowditch table II we take out 40 as the correction to be subtracted from the register reading to give the number of turns caused by the current at the depth required. In order to test the regularity of revolution, at some of the stations every alternate observation was made at the same depth, under the supposition that in short intervals of time great changes in velocity will not take place. These curves are surprisingly regular, and as the observations were taken for this test at 130 fathoms depth, where the correction is large, the regularity of the curves confirms in a measure the accuracy of the method of correction. It hardly seems possible that there can be an error in the greatest correction of 10 revolutions, which would be less than one one-hundredth of one knot.

In order to prevent the meter from being swept astern by the force of the current the following arrangement was provided: A strong wire called a jack-stay was attached to a boat anchor and three shot and sent to the bottom after the ship's anchor was down. The ship's anchoring rope was then veered so that the vessel dropped astern until the jack-stay wire was up and down; the meter was then attached to this wire by a metal rod and roller called a traveler. It was found that it was very difficult to keep this jack-stay from dragging over the bottom; it was therefore abandoned and the following substituted: When the ship's anchor was on the bottom a piece of line, the length of which depended on the depth of water, was attached to the anchoring rope; at the other end of the line were attached three shot and the jack-stay wire, and both the jack-stay and anchoring rope veered away together. The line was only to act as an anchor on the jack-stay to prevent it dragging, and the weight of the shot to keep it vertical. It was found to work very well.

The meter was lowered attached to the jack-stay wire by the traveler as described. The meter-wire was swept aft, forming a considerable curve with the greater depths, and it was a matter of doubt as to what was the actual depth of the meter below the surface. As deep as 100 fathoms the actual position was found by using a Bassnett's sounding-rod, which is a register of depth depending upon pressure. The proportion of wire to pay out to carry the meter to a certain depth was thus known for all but the greater depths, and with these judgment was used based on the experience of the others. At 65 fathoms from 6 to 30 fathoms more had to be veered. At 130 fathoms, from 20 to 60 fathoms additional.

The actual depth of the meter as given in the record I believe to be correct to within 5 per cent. Greater depths could have been obtained if we could have used heavier weights on the meter, but having but the one instrument I hesitated to do anything that would risk it until the season was successful in the amount and kind of the work attempted. The effect of the bight or middle of the wire being swept aft by the current would be to raise the meter above the depth desired into a stronger current. The register would then show all the fluctuations in the sub-currents that were found on the surface. The trustworthiness of the meter in the sub-currents is shown by the

variations, for in many instances the velocity of the sub-current did not increase or decrease with the surface, although in most instances it did.

The most serious difficulties in connection with the meter were these: The compass-needle was gold-plated, silver-plated, and covered with shellac, and in spite of these coverings the rust would come through; the needle became pitted and lost its directive force somewhat, but the latter was corrected by remagnetizing it by means of the Brush dynamo. The rust collected about the pivot and in a short time blunted it so that the needle would hardly move. Whenever a series of observations were completed, and oftentimes in the middle of a series, the meter was taken up and the pivot filed and the needle cleaned. Considerable trouble was experienced from sea-nettles, with which at times it seems the Gulf Stream abounds. These nettles are in appearance about like sewing-silk, and if one of them became attached to the registering gear in any way its motion was retarded. A thorough inspection was made each time, and if there was any doubt of the correctness of the reading of the register the observation was duplicated. Of course there are some errors which *may* have escaped notice, but every care was exercised, and, I believe, the errors are very few. The meter was only experimental—that is to say, it being the first of its kind, there was no certainty that it would work. It was found, however, that with the exceptions mentioned (disregarding the arrangement for locking the speed indicator), but one other change was necessary, which was to substitute a propeller with three blades instead of two. One or two additional changes have been made with the new meters, by which they can be taken apart more easily, but these are not essential for accuracy.

The original instructions received from your predecessor, dated January 27, directed me to make a series of observations in the Gulf Stream between Fowey Rocks and Gun Cay, to be followed by similar observations between Cuba and Yucatan, and these to be followed by another series at the first station. I first made five or six trial anchorages for the purpose of testing the gear, and in one of these, near the Yucatan Bank, I discovered evidence of tidal action at 75 fathoms depth. Surmising that perhaps a thoroughly exhaustive examination at Fowey Rocks could not be made, under certain circumstances, in the time allotted, I requested you, through the Hydrographic Inspector, for authority to modify the scheme laid out, if I should deem it for the best interest of the survey, after I had made the first set of observations. On the first set I felt confident that tidal action was noticeable, or at any rate something caused a fluctuation in the strength of the daily flow. I also found that the axis of the stream was not situated near the position supposed by Professor Bache. I found, too, that the strength of the current at some stations was on the surface, while in others it was below, and the contrary results I attributed to lack of observations. My conclusions were, therefore, that exhaustive research at one place would give more positive results to the survey in the cause of science and hydrography than only a partial examination at two places, and I trust that as you examine the record you will consider that my decision was well taken. It was my intention, in laying out a scheme of action to follow in taking the observations, to occupy certain stations at about the first and third quarters of the moon, and again at new and full moons, at exactly the same relative times at each. Could I have had good weather this scheme could have been carried out, but unfortunately good ordinary weather does not mean good anchoring weather in 500 fathoms of water. I found it impossible to follow any scheme exactly. With a moderate easterly breeze the west side of the stream was too rough; with a westerly one the east side had to be avoided. In any place we had to get under way at a squall if it was thought to be heavy. I presume many times that we did get under way we could have remained, but with no duplicate gear on board I was afraid to risk carrying it away until I had made a successful season. I feared, too, in case of an accident, there might be some loss of life. The anchoring rope with a strong current was probably standing a strain of eight or ten tons, the topping-lift and buffers even a greater strain, and with these forces distributed about the ship on both sides and aloft, if anything did go it could hardly miss injuring some one, if not worse. As the season progressed, and the weak points in the anchoring gear had been strengthened as defects appeared, we were at last able to ride through squalls of considerable force without fear of carrying away anything.

I presume in the future there will be many series of current observations across the Gulf Stream, and as this is the narrowest part of the stream, I have given it the name of "Cross Section A" (see sketch 37). The current stations I numbered in succession from west to east—1, 2, 3, 4, 5.

The second time I occupied a station I gave it, in addition to a number; a letter, thus, 1*a*, 2*a*, &c., and the third time, 1*b*, 2*b*, &c. (See sketch 38). The same number indicates observations taken at about the same position. The observations were taken at  $3\frac{1}{2}$ , 15, 30, 65, and 130 fathoms, and at one or two stations at 2 fathoms and 210 fathoms. During the earlier part of the season the meter was allowed an interval of thirty minutes to register at all depths, except in some instances, when duplicate observations were taken. During the latter part of the season the observations at  $3\frac{1}{2}$  fathoms generally took fifteen minutes, at 15 fathoms twenty minutes, and other depths thirty minutes. It was thought that the multiplication of an error in the record of the currents of the upper strata, where the total correction in any event would be small, would give results of the same correctness as in the lower strata, where the corrections are large. In other words, the error at  $3\frac{1}{2}$  fathoms multiplied by 4 would be as correct as the error at 130 fathoms multiplied by 2.

The observations for velocity taken on stations 1, 2, 3, 4, and 5 are more liable to error than on the other stations, for the reason that during these observations the propeller was used to lock the velocity apparatus, and an uncertainty exists as to the exact length of time required to completely lock. It is thought, however, that the greatest possible error due to this defect would be expressed by a number of revolutions equal to one-third the depth at which the observation is taken—that is, at 30 fathoms, a possible error of ten revolutions, and so on. On all other stations it is believed that an error of ten revolutions would be excessive on even the greatest depth.

Efforts were made to obtain temperatures at the various depths by attaching thermometers to the meter wire, but they were not successful. The meter wire had a continual vibration when in use, and the index of the thermometers (Miller-Casella) would become shaken up, in some instances even into the bulb. The Negretti-Zambra thermometers were found to turn by the force of the current in too short a time to allow them to register properly. The observations for temperature were consequently given up during the latter part of the season, and it is proposed for next season to have a small rubber arrangement made by which the vibration will be overcome and the thermometers register correctly.

The appended curves of currents at same depths (illustrations 41 to 46, inclusive) represent the actual observations plotted according to time and revolutions of the meter. In strict truth, our whole knowledge of the currents is confined to the observations, and perhaps it is unwarranted to connect the points by curves instead of straight lines. I believe, however, that the curves more truly represent the actual change, or the condition of the currents at any time. On these sheets, near the middle or at the lower edges, are shown the times of the meridian passage (upper transit) of the moon, and the declination each day. All times are local apparent time.

On these curves doubtful observations are inserted, but are connected by light dotted lines. The vertical curves in heavy black broken lines (illustration 43) are the means of the actual observations; those in lighter broken lines are constructed from the means taken from the curves of velocities at the same depth. Illustration 40 shows the approximate declination of the moon during the season, with the position of each station with reference to the declination and phase plotted at its proper place. Illustration 39 shows the profile of the bottom on the upper half, and below is a curve which represents a portion of the monthly variation in velocity of the current at No. 1 station. The points are plotted on the co-ordinates of the moon's declination and velocity, the mean of the surface velocity and the approximate declination for the middle time being taken. From this curve, which includes declinations from about  $6^{\circ}$  south, increasing to the greatest southing, and thence to about  $15^{\circ}$  north, it will be seen that apparently the velocity remains nearly constant until the greatest declination is reached, when it increases rapidly until a day or two after the greatest southing, and then decreases again, probably to go through the same fluctuation with northern declination. That this is an invariable rule there are no means of determining with only the meager data thus far obtained, and I have only introduced this curve as an assistance in laying out a scheme for future investigation. That there is a diurnal fluctuation in the velocity of the stream I think cannot be doubted, and it would seem that this daily variation may have given rise to the commonly accepted theory that the axis of the stream varies in position, sometimes daily. The axis of the stream, or the line of maximum velocity, may change somewhat, but the evidence of this change in any of our observations is wanting, with the exception possibly of station No. 5, where a difference of nearly one knot was observed with the same declination of the moon on different months. So many other factors may combine to cause fluctuations, such as





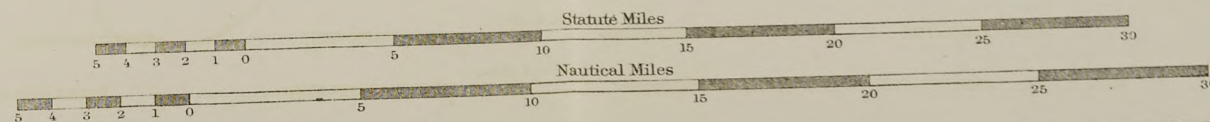
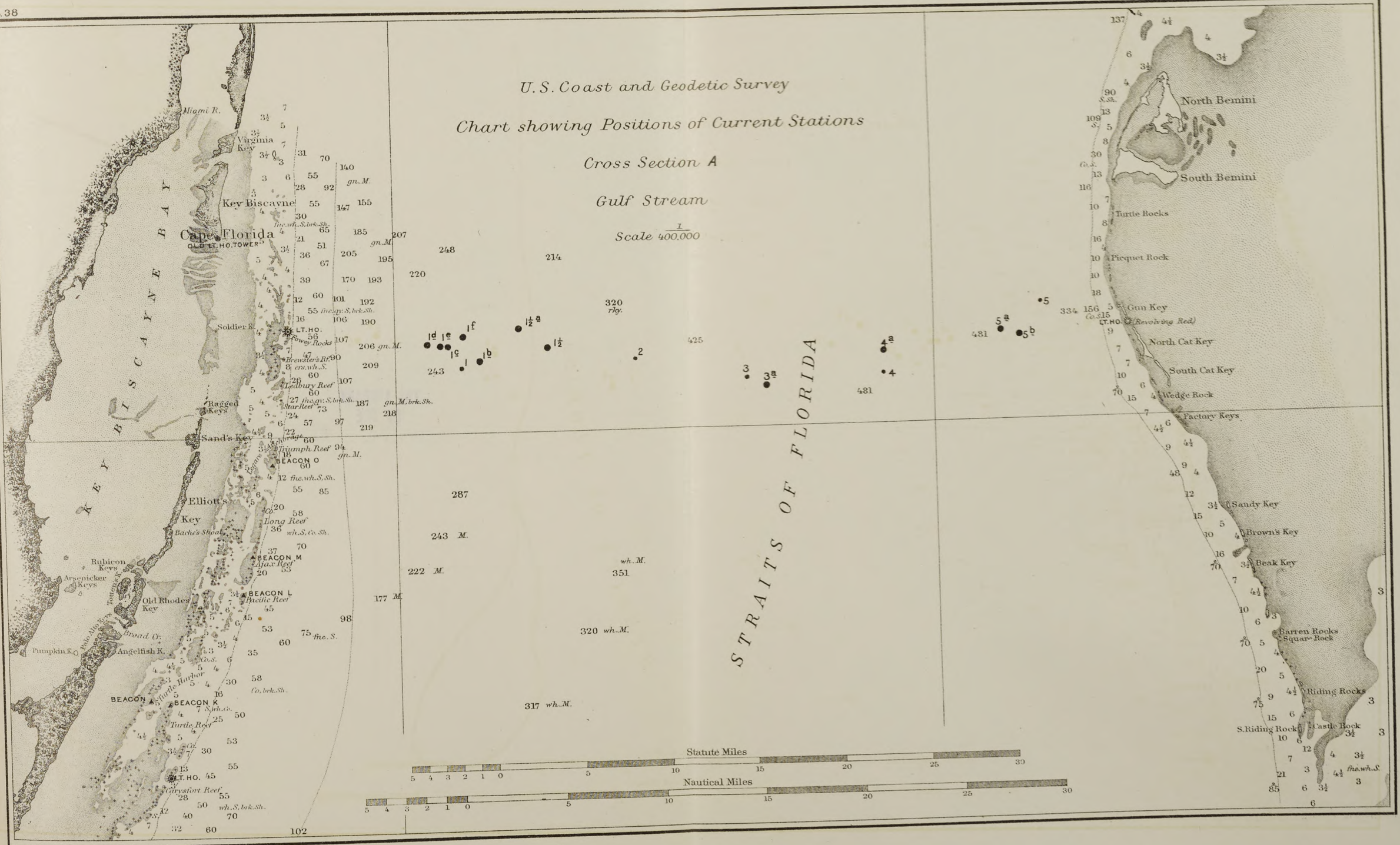


100

U. S. Coast and Geodetic Survey  
 Chart showing Positions of Current Stations  
 Cross Section A  
 Gulf Stream

Scale  $\frac{1}{400,000}$

STRAITS OF FLORIDA



1-1-1-1  
1-1-1-1



DEEP SEA CURRENT WORK  
GULF STREAM

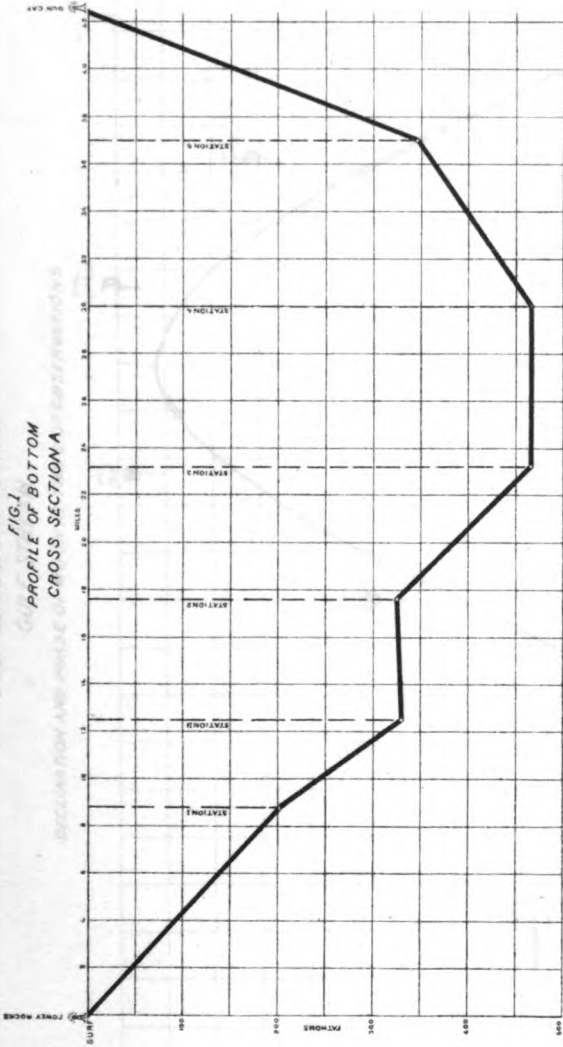
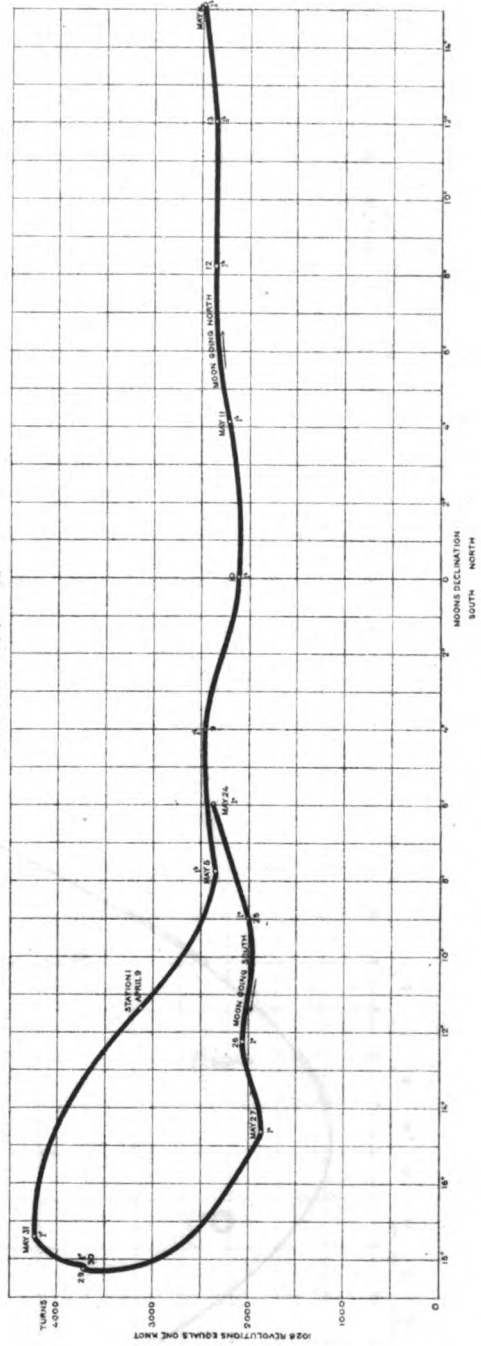


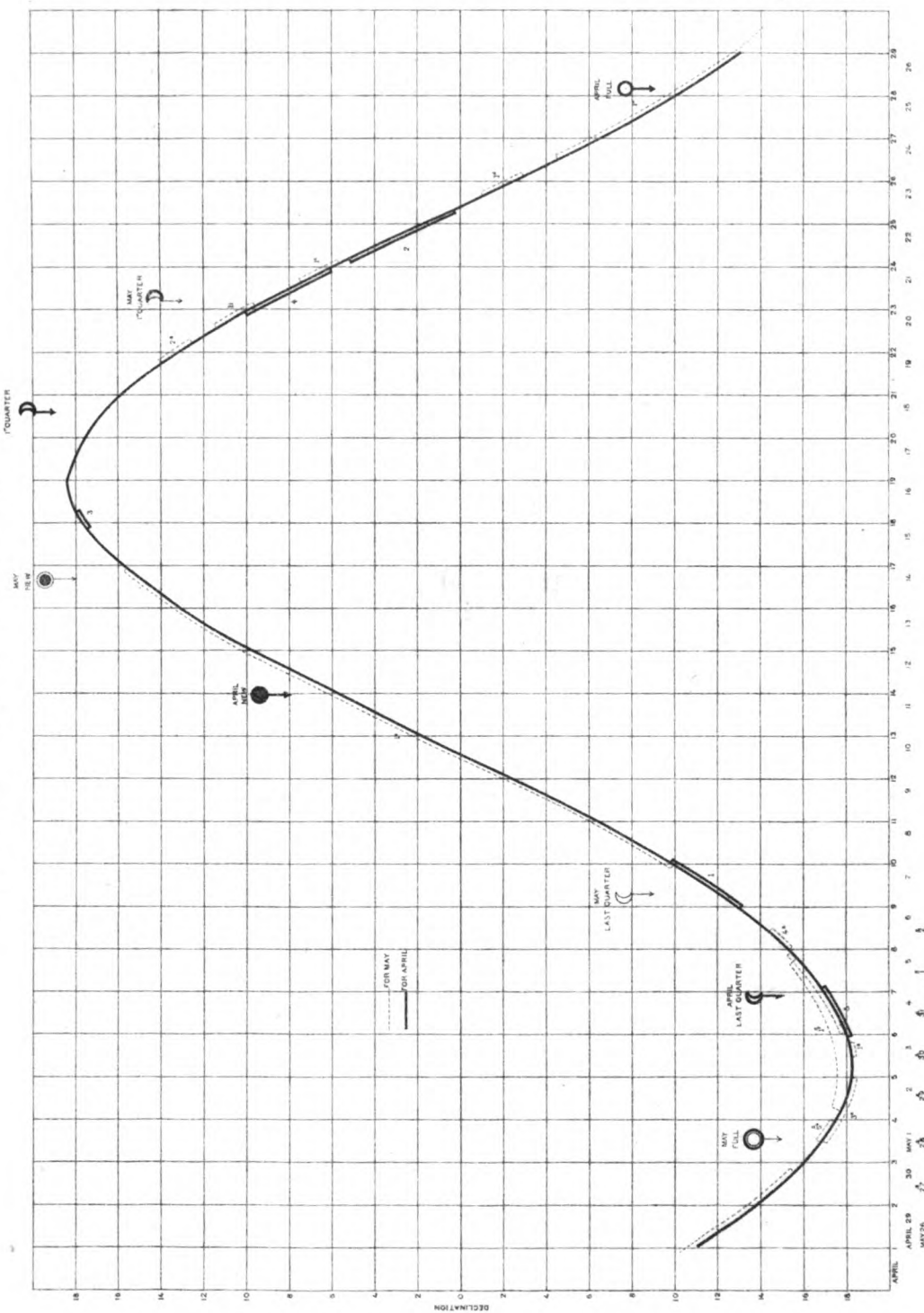
FIG. 2  
CURVE SHOWING VARIATION IN VELOCITY OF CURRENTS WITH CHANGES IN MOON'S DECLINATION  
STATIONS 1, 1<sup>1</sup>/<sub>2</sub>, 2, & 2<sup>1</sup>/<sub>2</sub>

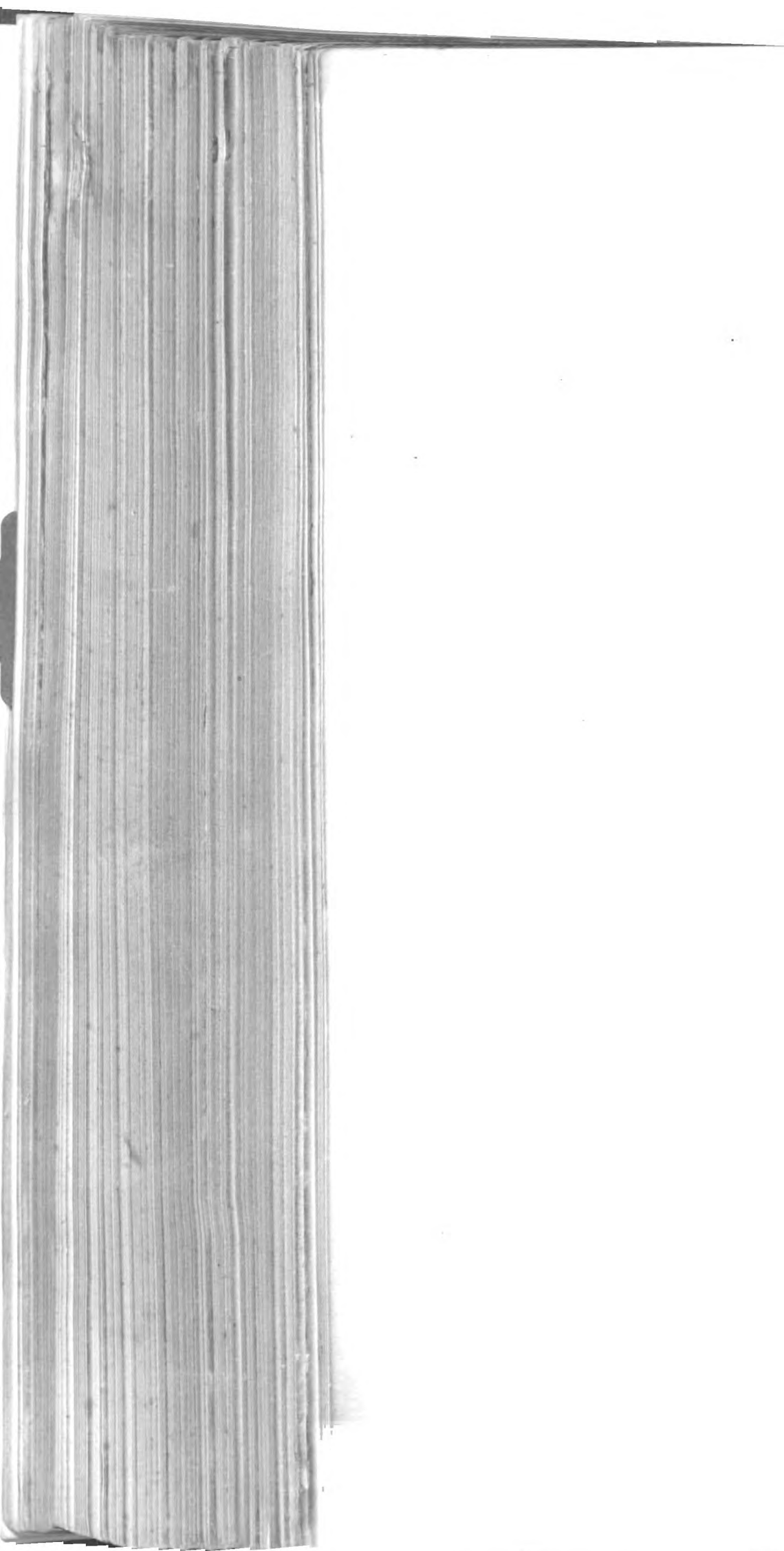


1 1 1  
1 1 1

DEEP SEA CURRENT WORK  
GULF STREAM

DECLINATION AND PHASE OF MOON AT TIMES OF OBSERVATIONS



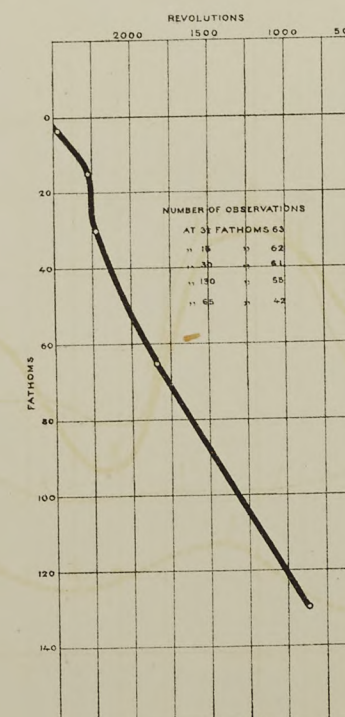
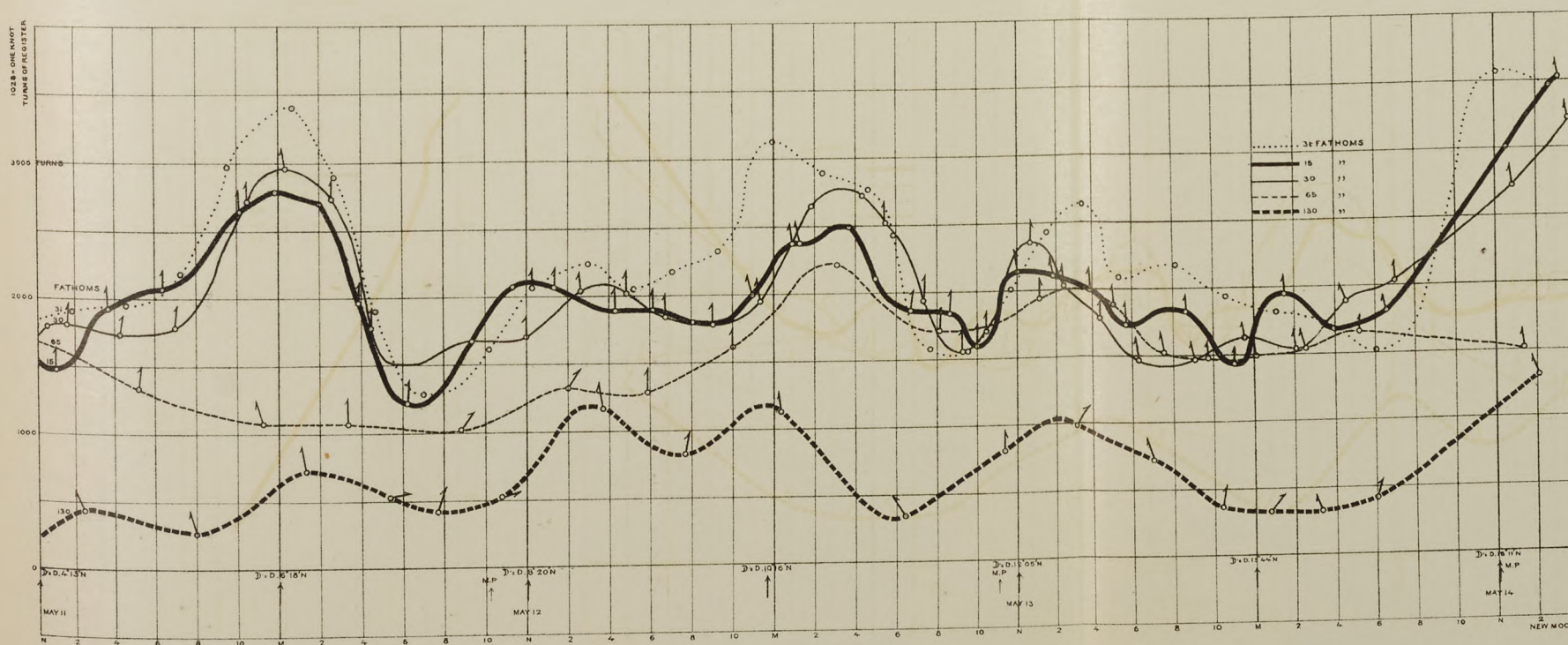
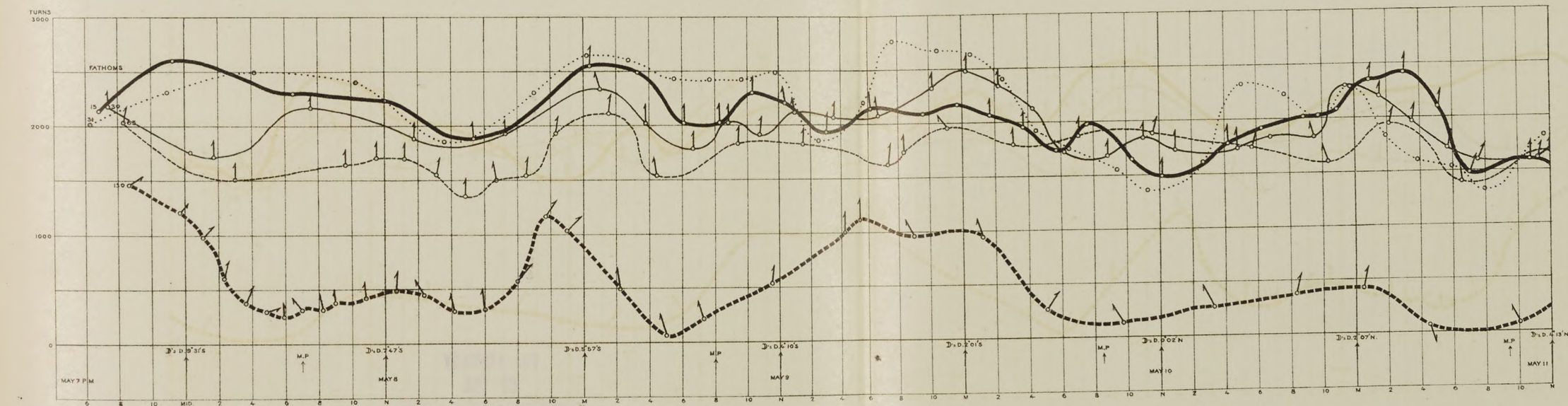




# OBSERVATIONS OF CURRENTS GULF STREAM

STATION 1<sup>b</sup> CROSS SECTION A

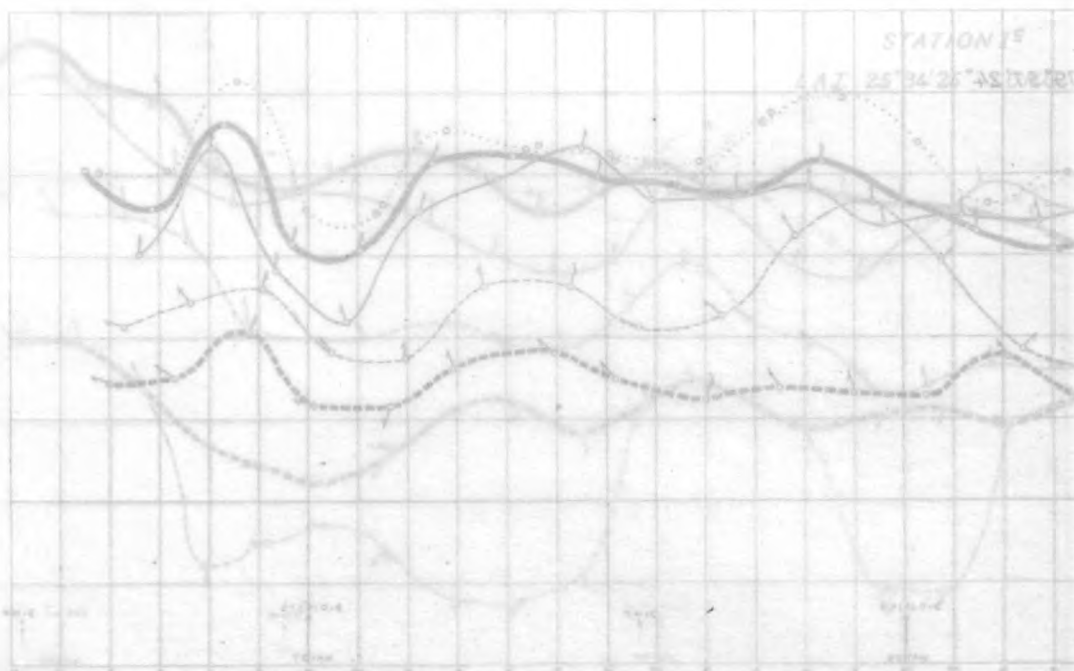
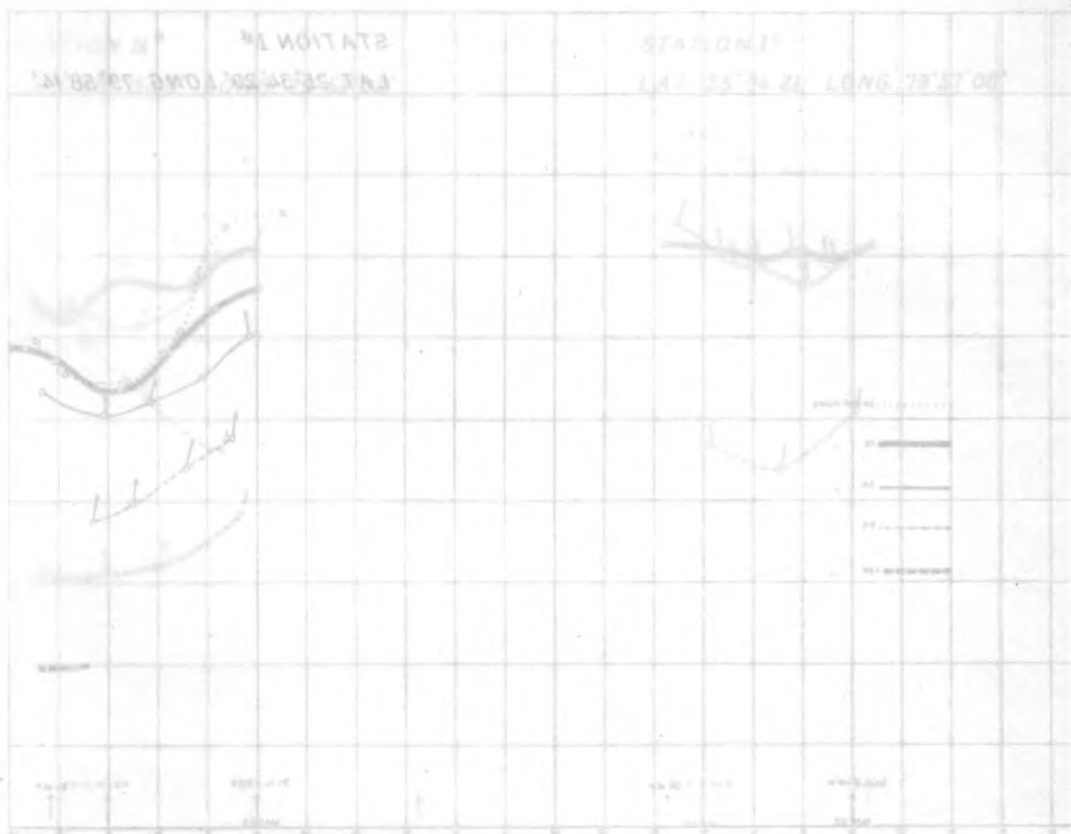
LAT. 25° 33' 33" LONG. 79° 55' 25"



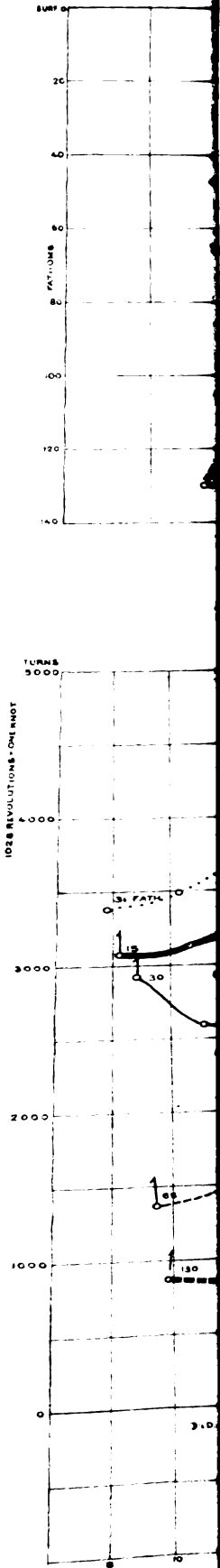


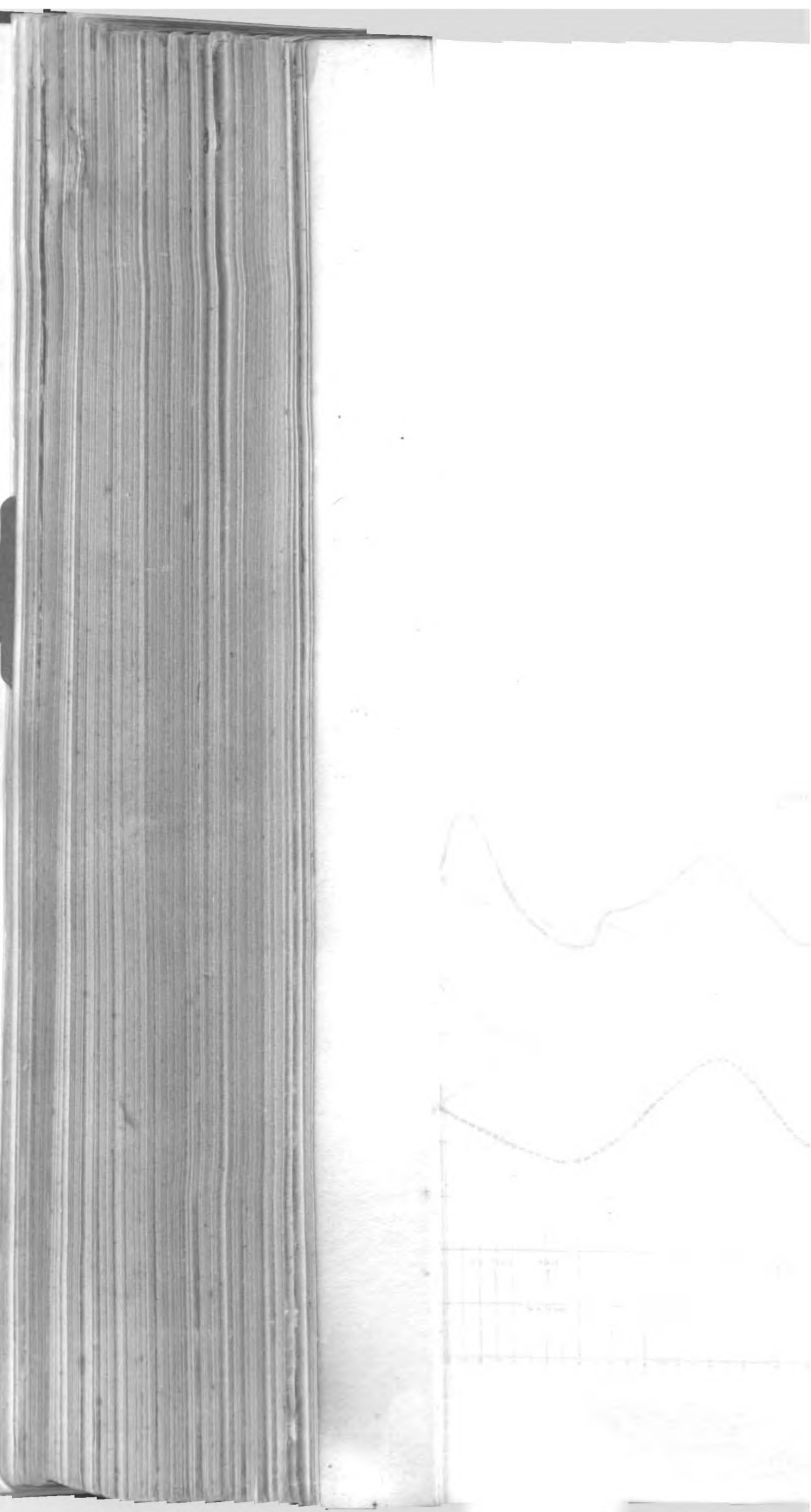


CURRENTS  
GULF STAKE

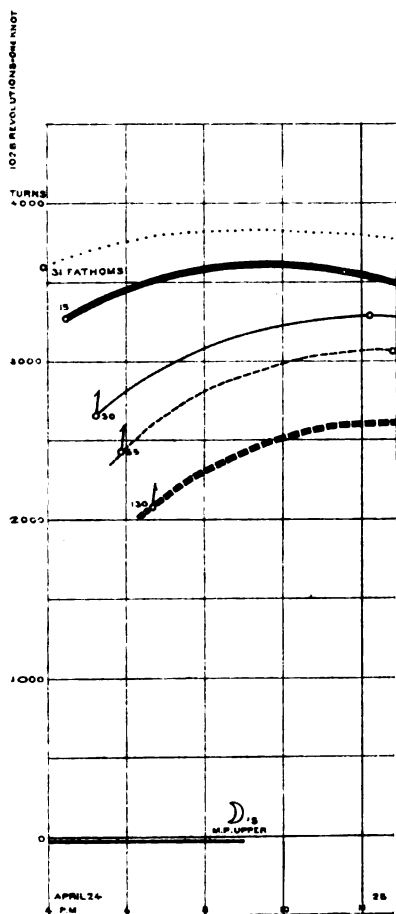
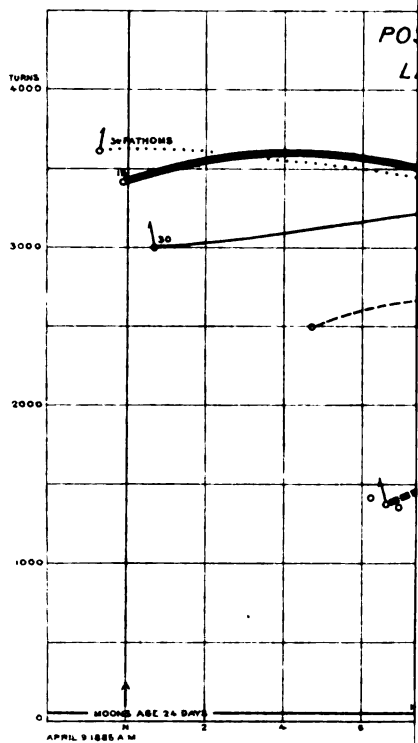


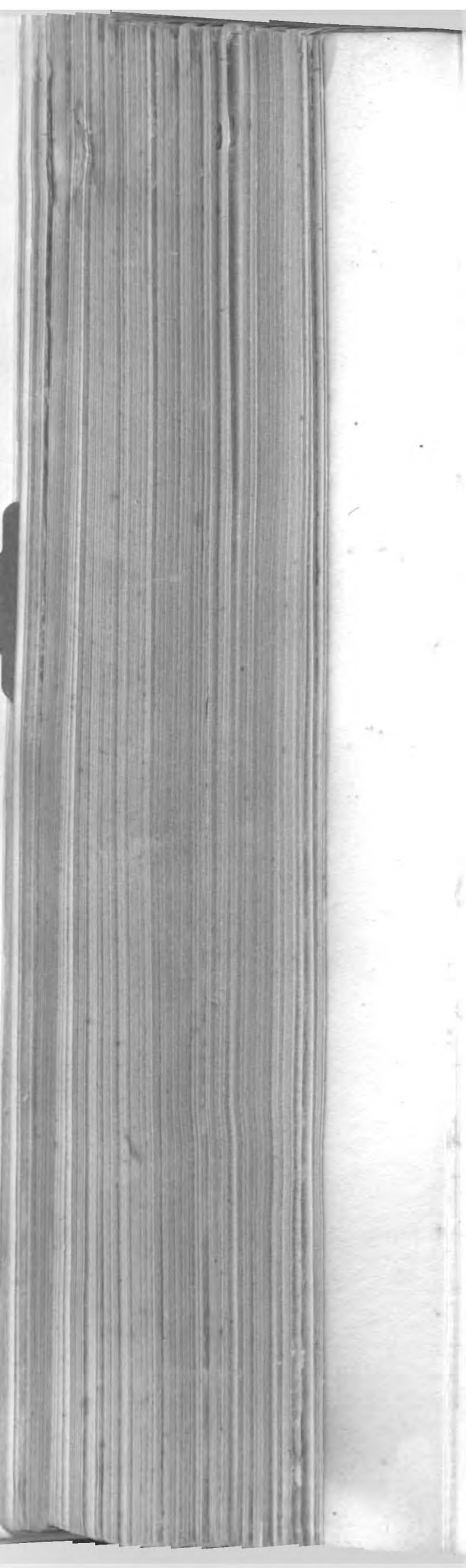






No. 44





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strong easterly or westerly winds in the Gulf of Mexico, banking up or reducing the level of the fountain head; the same to the northward and eastward beyond the Little Bahamas; much difference in barometric level between the Gulf of Mexico and the Atlantic, &c., that the evidence from one observation at station No. 5 I do not consider in other light than a variation to the rule. The observations taken for many days at station No. 1 seem to point to a fairly regular flow, and I think it probable that any abnormal cause will affect the whole surface flow, only to retard or accelerate the velocity, and not to change the position of the line of greatest velocity abruptly, or, indeed, to any very great extent.

The velocity of the surface current at times was less than the velocity of the sub-currents. On line 1b this is particularly noticeable, where, in every instance, at about the time of the minimum daily velocity, the surface speed fell below that at 15 fathoms, and at times below that at 30 fathoms. In other words, the amount of the daily fluctuation was greatest at the surface. That this was caused by local winds there is no evidence. During this week the winds were light and blowing from no one direction longer than a few hours, and at times when the wind was northerly the velocity was greatest, and when southerly the current was weak. In fact, I could discover no connection between the velocity of the current and the wind, either at the time it was blowing or afterwards, which would cause the variations in the flow of the former. It will be seen from the vertical curves (illustration 43) that (while the surface velocity fell below the sub-surface at times) the mean velocity at the surface was greater than any of those below. The mean depth of the water at the stations used in vertical curve "B" is about 350 fathoms, and for curve "A" 204 fathoms. Continuing the curves it will be seen that they reach zero velocity at about the time they reach the bottom.

This, however, does not seem to be true, for the vertical curve of station 5a, shown on illustration 45. At this station the velocities of the sub-currents are more nearly equal to the surface than on any other station, and the daily changes are less. I regret that there are any apparently unreconcilable results in the record obtained, but perhaps when it is studied by some of the scientific gentlemen who have devoted their lives to this and kindred subjects, many points which seem to be inconsistencies now will be solved, and with the addition of the record of one or two more successful seasons at the same place some of the laws governing this wonderful river of the ocean will be made plain.

Too much credit for the success of the season's work cannot be given to the officers of the vessel. They performed their duty in every particular with the greatest care, zeal, and intelligence, and in work so continuous it is a wonder that there are not more erroneous readings or recordings than there seem to be in this record.

Respectfully, &c.,

J. E. PILLSBURY,  
*Lieutenant, U. S. N.,*  
*Assistant Coast and Geodetic Survey.*

Mr. F. M. THORN,  
*Superintendent Coast and Geodetic Survey.*



## APPENDIX No. 15.

### NOTE ON A DEVICE FOR ABBREVIATING TIME REDUCTIONS.

By C. S. PEIRCE, Assistant.

The simple suggestion that I wish to make is that by multiplying the observed times of transit (after applying a provisional correction and subtracting the right ascension) by the cosine of the declination, the field reduction is much facilitated, and the labor of the least-square reduction is decidedly lessened. This arises from two circumstances: First, that the azimuth, level, and collimation coefficients are much quicker taken out, and for northern stars quicker used; and second, that the weights to be assigned to the observations have a small range and are readily applied, while in a rough reduction they may be omitted without disadvantage.

The following are the values of the coefficients:

	Old way.	New way.
Azimuth.	$\sin \zeta \sec \delta$	$\sin \zeta$
Level.	$\cos \zeta \sec \delta$	$\cos \zeta$
Collimation.	$\pm \sec \delta$	$\pm 1$

The old coefficients have to be taken out of a table of double-entry (which is always disagreeable), and this table extends over eight pages quarto at least. The new coefficients are taken instantly and with greater accuracy from a single-page three-place table of sines and cosines. The old table is of no use for any other purpose, but the little table of trigonometric functions is invaluable for a thousand purposes, and ought to be at every observer's elbow, whether this way of reducing time-observations is used or not. The old coefficients have often three significant figures, even when only two places of decimals are used; but the new ones never exceed unity, and a two-by-two place multiplication table, such as Waldo's, is all that is required with them.

The weights of times of transit of stars of different declinations, according to the researches of Mr. Schott, agreeing with the formula of Dr. Albrecht, are given by the formulæ

$$p = \frac{1}{1 + \left(\frac{36}{63}\right)^2 \tan^2 \delta} \text{ for the C. S. large instruments,}$$

$$p = \frac{1}{1 + \left(\frac{63}{80}\right)^2 \tan^2 \delta} \text{ for the C. S. small instruments.}$$

The weights for  $D = d \cos \delta$ , or the residual times multiplied by the cosines of the declinations, are the above multiplied by  $\sec^2 \delta$ , which gives

$$P = \frac{1}{0.663 + 0.337 \cos 2 \delta} \text{ for the large instruments,}$$

$$P = \frac{1}{0.81 + 0.19 \cos 2 \delta} \text{ for the small instruments.}$$

Thus, for the large instruments, the weight ranges only from 1 at the equator to 3.06 at the pole, and for the small instruments from 1 to 1.6. The old way of reducing observations, as if all the times had equal weight, is entirely inadmissible even in a rough field-reduction. But after multiplying by  $\cos \delta$ , observations with the small instruments may be treated as of equal weight; while with large instruments, in a not very refined reduction, we may use the rule that  $P=1$  from the equator to  $41^\circ$  of declination,  $P=2$  from  $41^\circ$  to  $70^\circ$ , and  $P=3$  from  $70^\circ$  to the pole. It will never be worth while to use more than one place of decimals for the weights, which are given in the following table:

Declination.	P	.7 P	Declination.	P	.7 P
0			0		
0	1.00	0.70	50	1.65	1.15
5	1.01	0.71	55	1.82	1.27
10	1.03	0.72	60	2.02	1.41
15	1.05	0.74	65	2.24	1.57
20	1.09	0.76	70	2.47	1.73
25	1.14	0.80	75	2.69	1.88
30	1.20	0.84	80	2.88	2.02
35	1.28	0.90	85	3.02	2.11
40	1.38	0.97	90	3.06	2.14
45	1.51	1.06			

In a field-reduction, the unknown chronometer correction being small, the azimuth will be determined in each position by a north and a south star, and the residual  $D$  calculated for each star. This is corrected for aberration, and then the simple half difference of the mean residuals in the two positions of the instrument is the collimation, while the half sum (taking only high stars) is the chronometer error multiplied by the cosine of the latitude.

In reducing by least squares, we have the same quantities to calculate as by the old way; but these are obtained in a different manner, as shown by the following formulæ. The multiplications are generally easier by the new method.

*Quantities used in least square work.*

$$\begin{aligned}
 p &= P \cos^2 \delta \\
 pA &= P \cos \delta \sin \zeta \\
 pC &= \pm P \cos \delta \\
 pd &= PD \cos \delta \\
 pA^2 &= P \sin^2 \zeta \\
 pAC &= \pm P \sin \zeta \\
 pAd &= PD \sin \zeta \\
 pC^2 &= P \\
 pCd &= PD \\
 \sqrt{p} \cdot d &= \sqrt{P} \cdot D.
 \end{aligned}$$

The following is an example: On 1885, April 5, I observed time with transit No. 5 (large size), at Key West, latitude  $+ 24^\circ 33\frac{1}{2}'$ . The correction of the chronometer had been found to be

$$\begin{aligned}
 \text{April 3, } 10^{\text{h}} \text{ sid. t.} &+ 12^{\text{s}}.07 \\
 \text{April 4, } 10^{\text{h}} \text{ sid. t.} &+ 11^{\text{s}}.34.
 \end{aligned}$$

It was, therefore, supposed to be about  $+10^{\circ}.60$  on the 5th at  $10^h$ , with a diminution of  $0^{\circ}.01$  every twenty minutes. The level was observed as follows:

			Corrected for pivots.		C
	h.	m.	d.	s.	
Clamp E.	9	18	— 19.1	— 20.7	== — 0.420
	9	48	— 14.3	— 15.9	== — 0.323
Clamp W.	9	52	— 22.4	— 20.8	== — 0.422
	10	48	— 20.4	— 18.8	== — 0.382

The stars observed, with their constants, were as follows:

Star.	Approx. time.	$\delta$	$\cos \delta$	$\cos \zeta$	$\sin \zeta$	$p$ .
<i>Clamp E.</i>						
$\epsilon$ Argus.	h. m.	°	°			
	9 14	— 58.8	+ 83.3	.518	.117	+ .994 2.0
$\theta$ Ursæ Majoris.	25	+ 52.2	— 27.6	.613	.886	— .463 1.7
$\iota$ Leonis Minoris.	28	+ 36.9	— 12.3	.800	.977	— .213 1.3
$\alpha$ Leonis.	35	+ 10.4	+ 14.2	.984	.969	+ .245 1.0
$\epsilon$ Leonis.	39	+ 24.3	+ 0.3	.911	1.000	+ .005 1.1
$\mu$ Leonis.	46	+ 26.5	— 1.9	.895	.999	— .033 1.2
<i>Clamp W.</i>						
$\nu$ Hydræ.	59	— 12.5	+ 37.1	.976	.798	+ .601 1.0
$\gamma$ Leonis.	10 13	+ 20.4	+ 4.2	.937	.998	+ .073 1.1
$\eta$ Draconis.	25	+ 76.3	— 51.7	.237	.620	— .785 2.7
$\delta$ Leonis Minoris.	37	+ 23.8	+ 0.8	.915	1.000	+ .014 1.1
$\beta$ Ursæ Majoris.	55	+ 57.0	— 32.4	.545	.844	— .536 1.9

We begin the computation with two zenith stars observed in the two positions. The following gives the data and computation:

	Clamp E. $\epsilon$ Leonis.	Clamp W. $\delta$ Leon. Min.
Chron. time.	h. m. s.	h. m. s.
	9 39 10.65	10 37 01.63
Assumed correction.	+ 10.61	+ 10.58
$t$	9 39 21.26	10 37 12.21
$a$	9 39 20.92	10 37 11.47
$t - a$	+ 0.34	+ 0.74
$(t - a) \cos \delta$	+ 0.31	+ 0.68
$\delta \cos \zeta$	— 0.37	— 0.37
	— 0.06	+ 0.31
Approx. azimuth.	.00	— 0.01
	— 0.06	+ 0.30
Corrected for aberration.	— 0.08	+ 0.28



The mean between the final figures or  $\frac{1}{2}(-0^{\circ}.08 + 0^{\circ}.28) = +0^{\circ}.10$  is the chronometer error multiplied by the cosine of the latitude. Multiplying by the secant, or 1.1, we get  $+0^{\circ}.11$  as the first approximation to the clock error. We therefore assume that instead of  $+10^{\circ}.60$  at  $10^h$ , the error was  $+10^{\circ}.49$ , with a diminution of  $0^{\circ}.01$  every 17 minutes.

We now proceed to find the azimuth. The data and computations are as follows:

## CLAMP E.

	$\epsilon$ Argus.	$\theta$ Ursæ Majoris.
	h. m. s.	h. m. s.
Chron. time.	9 13 53.76	9 25 0.55
Correction.	+ 10.52	+ 10.51
$t$	9 14 04.28	9 25 11.06
$a$	9 14 2.98	9 25 11.25
$t-a$	+ 1.30	- 0.19
$(t-a) \cos \delta$	+ 0.67	- 0.12
$b \cos \zeta$	- 0.05	- 0.33
	+ 0.62	- 0.45
$\sin \zeta$	0.994	0.463

The difference between  $+0^{\circ}.62$  and  $-0^{\circ}.45$  or  $+1^{\circ}.07$  is due to the difference between the two sines or  $+1.457$ . Hence,  $a = \frac{1.07}{1.457} = +0^{\circ}.734$ . Similarly, in the other position, we have the following data and calculations:

## CLAMP W.

	$\nu^2$ Hydræ.	$\eta$ H. Draconis.	$\beta$ Ursæ Majoris.
	h. m. s.	h. m. s.	h. m. s.
Chron. time.	9 59 23.91	10 25 9.92	10 54 45.70
Corr.	+10.49	+10.47	+10.46
$t$	9 59 34.40	10 25 20.39	10 54 56.16
$a$	9 59 33.51	10 25 21.17	10 54 55.93
$t-a$	+ 0.89	- 0.78	+ 0.23
$(t-a) \cos \delta$	+ 0.87	- 0.19	+ 0.13
$b \cos \zeta$	- 0.32	- 0.25	- 0.34
	+ 0.55	- 0.44	- 0.21
$\sin \zeta$	+ 0.601	- 0.785	- 0.536

Combining with  $\nu^2$  Hydræ, first,  $\eta$  H. Draconis, we get

$$a = \frac{+0.99}{+1.386} = 0^{\circ}.714$$

and second,  $\beta$  Ursæ Majoris, we have

$$a = \frac{+0.76}{+1.137} = 0^{\circ}.668$$

As the former star has a weight of 3 and the latter of 2, we conclude

$$a = +0^{\circ}.696.$$

Applying this value of the azimuth to the high stars, we get the following results:

	Chron. time.	Corr.	Seconds of $a$	$t - a$	$(t - a)$ $\cos \delta$	Level.	Az.	
<i>Clamp E.</i>								
10 Leonis Minoris.	h. m. s. 9 28 01.73	+10.51	s. 12.17	+0.07	+0.06	-0.36	+0.16	-0.14
$\alpha$ Leonis.	34 52.22	+10.51	02.31	+0.42	+0.41	-0.36	-0.18	-0.13
$\epsilon$ Leonis.	39 10.65	+10.50	20.92	+0.23	+0.21	-0.37	0.00	-0.16
$\mu$ Leonis.	46 04.68	+10.50	14.91	+0.27	+0.24	-0.37	+0.02	-0.11
							Mean.	-0.14
							Corrected for aberration.	-0.16
<i>Clamp W.</i>								
$\gamma^1$ Leonis.	10 13 29.71	+10.48	39.58	+0.61	+0.57	-0.40	-0.05	+0.12
41 Leonis Minoris.	37 01.63	+10.47	11.47	+0.63	+0.58	-0.40	-0.01	+0.17
							Mean.	+0.14
							Corrected for aberration.	+0.12

It therefore appears that the collimation is  $+0^{\circ}.14$  and the additional chronometer correction  $+0^{\circ}.02$ , making the correction at  $10^h$ ,  $+10^m.51$ . We now apply these corrections to all the stars, with the following results:

Star.	$t - a$	$(t - a)$ $\cos \delta$	Az.	Level.	Coll. and Ab.	D	P
<i>Clamp E.</i>							
$\epsilon$ Argus.	+ 1.32	+ 0.68	- 0.73	- 0.04	+ 0.12	+ 0.03	2
$\theta$ Ursæ Majoris.	- 0.17	- 0.10	+ 0.34	- 0.33	+ 0.12	+ 0.03	2
10 Leonis Minoris.	+ 0.09	+ 0.07	+ 0.16	- 0.36	+ 0.12	- 0.01	1
$\alpha$ Leonis.	+ 0.44	+ 0.43	- 0.18	- 0.36	+ 0.12	+ 0.01	1
$\epsilon$ Leonis.	+ 0.25	+ 0.23	+ 0.00	- 0.37	+ 0.12	- 0.02	1
$\mu$ Leonis.	+ 0.29	+ 0.26	+ 0.02	- 0.37	+ 0.12	+ 0.03	1
<i>Clamp W.</i>							
$\nu^2$ Hydræ.	+ 0.91	+ 0.89	- 0.42	- 0.32	- 0.16	- 0.01	1
$\gamma^1$ Leonis.	+ 0.63	+ 0.59	- 0.05	- 0.40	- 0.16	- 0.02	1
9 H Draco.	- 0.76	- 0.18	+ 0.55	- 0.25	- 0.16	- 0.04	3
41 Leonis Minoris.	+ 0.65	+ 0.59	- 0.01	- 0.40	- 0.16	+ 0.02	1
$\beta$ Ursæ Majoris.	+ 0.25	+ 0.14	+ 0.37	- 0.34	- 0.16	+ 0.01	2

Taking the weighted means of D on the two sides, we see that the collimation has to be reduced by  $0^{\circ}.01$ , while the chronometer correction remains unchanged. We then have for D

Clamp E.	Clamp W.
+ 0.02	0.00
+ 0.02	- 0.01
- 0.02	- 0.03
0.00	+ 0.03
- 0.03	+ 0.02
+ 0.02	

This concludes the field-reduction, and the magnitudes of the residuals illustrate its superiority over old methods. Finally, we will calculate further corrections by least squares. The quantities for the normal equations are calculated as follows:

$P \cos^2 \delta$	$P \cos \delta \sin \zeta$	$\pm P \cos \delta$	$PD \cos^2 \delta$	$P \sin^2 \zeta$	$\pm P \sin \zeta$	$PD \cos \delta \sin \zeta$	$\pm PD \cos \delta$
<i>Clamp E.</i>							
0.5	+ 1.0	+ 1.0	+ 0.01	2.0	+ 2.0	+ 0.02	+ 0.02
0.6	- 0.5	+ 1.0	+ 0.01	0.4	- 0.8	- 0.01	+ 0.02
0.8	- 0.2	+ 1.0	- 0.02	0.1	- 0.3	0.00	- 0.02
1.0	+ 0.2	+ 1.0	0.00	0.1	+ 0.3	0.00	0.00
0.9	0.0	+ 1.0	- 0.03	0.0	0.0	0.00	- 0.03
0.9	0.0	+ 1.0	+ 0.02	0.0	0.0	0.00	+ 0.02
4.7	+ 0.5	+ 6.0	- 0.01	2.6	+ 1.2	+ 0.01	+ 0.01
<i>Clamp W.</i>							
1.0	+ 0.6	- 1.0	0.00	0.4	- 0.6	0.00	0.00
1.0	+ 0.1	- 1.0	- 0.01	0.0	- 0.1	0.00	+ 0.01
0.2	- 0.5	- 0.6	0.00	1.6	+ 2.1	- 0.02	+ 0.02
0.9	0.0	- 1.0	+ 0.03	0.0	0.0	0.00	- 0.03
0.6	- 0.6	- 1.0	+ 0.01	0.5	+ 1.0	- 0.01	- 0.02
3.7	- 0.4	- 4.6	+ 0.03	2.5	+ 2.4	- 0.03	- 0.02

The normal equations themselves are:

$$\begin{array}{rclclclcl}
 & & & & & & & s. \\
 8.4 t & + & 0.5 a & - & 0.4 a^1 & + & 1.4 c & = + 0.02 \\
 0.5 & + & 2.6 & & & + & 1.2 & = + 0.01 \\
 - 0.4 & & & + & 2.5 & + & 2.4 & = - 0.03 \\
 1.4 & + & 1.2 & + & 2.4 & + & 16 & = - 0.01
 \end{array}$$

The solution is

$$t = + .001 \quad a = + .003 \quad a^1 = - .012 \quad c = + .001$$

So that the field reduction cannot be improved.

I will add that it seems to me that this mode of reduction will be much more easily understood by inexperienced computers than the old one.

## APPENDIX No. 16.

### ON THE INFLUENCE OF A NODDY ON THE PERIOD OF A PENDULUM.

By C. S. PEIRCE, Assistant.

Suppose a noddy, adjusted to accord with a reversible pendulum, remain on the pendulum-support throughout the experiments to determine gravity. How much can the results be affected by this circumstance?

Let us use this notation:

$l$  and  $l'$ , the lengths of the single pendulums corresponding to the pendulum and noddy, respectively; that is, in each case the square of the radius of gyration divided by the distance between the center of mass and center of rotation;

$\mu$  and  $\mu'$ , the ratio of any linear displacement of the support to the angular displacement of the pendulum or noddy required to produce it;

$\tau$  and  $\tau'$  the natural periods of pendulum and noddy;

$T$  the period of either harmonic constituent of the motion.

Then, the formula, easily derived from my paper on two pendulums on one support, is:

$$T^2 = \frac{1}{2} \left\{ \left(1 + \frac{\mu}{l}\right) \tau^2 + \left(1 + \frac{\mu'}{l'}\right) \tau'^2 \right\} \pm \sqrt{\frac{1}{4} \left\{ \left(1 + \frac{\mu}{l}\right) \tau^2 - \left(1 + \frac{\mu'}{l'}\right) \tau'^2 \right\}^2 + \frac{\mu \mu'}{l l'} \tau^2 \tau'^2}$$

Any increase of  $\tau'$  always produces an increase of  $T$ ; and of the two values of  $T^2$ , one is always smaller, the other greater than

$$\left(1 + \frac{\mu}{l}\right) \tau^2$$

Consequently, the greatest effect is produced when one value of  $T^2$  is as much greater as the other is less than

$$\left(1 + \frac{\mu}{l}\right) \tau^2$$

that is, when

$$\left(1 + \frac{\mu'}{l'}\right) \tau'^2 = \left(1 + \frac{\mu}{l}\right) \tau^2$$

In this case,

$$T^2 = \left(1 + \frac{\mu}{l}\right) \tau^2 \pm \sqrt{\frac{\mu \mu'}{l l'}} \tau^2 \tau'^2$$

Denote by  $M$  and  $M'$  the masses of the pendulum and noddy, respectively, and by  $h$  and  $h'$  the distance in each between the center of mass and the center of rotation. Then

$$\mu \tau^2 : \mu' \tau'^2 = \frac{M h}{l} : \frac{M' h'}{l'}$$

and

$$\sqrt{\frac{\mu \mu'}{l l'}} \tau^2 \tau'^2 = \frac{\mu}{l} \tau^2 \sqrt{\frac{\mu' \tau'^2 l'}{\mu \tau^2 l}} = \frac{\mu}{l} \tau^2 \frac{l}{l'} \sqrt{\frac{M' h'}{M h}}$$

Assuming

$$\frac{M'}{M} = \frac{1}{100}, \frac{h'}{h} = \frac{1}{36}$$

for heavy end down,  $\frac{1}{12}$  for heavy end up, and  $\frac{l}{v} = 20$ , it would follow that the effect of the noddy might be as great as  $\frac{1}{3}$  of the flexure with heavy end down, and as  $\frac{1}{\sqrt{3}}$  times the flexure with heavy end up. But it could not produce a sensible effect in both positions.

## APPENDIX No. 17.

### ON THE EFFECT OF UNEQUAL TEMPERATURE UPON A REVERSIBLE PENDULUM.

By C. S. PEIRCE, Assistant.

The upper part of a pendulum swinging in a room not very lofty is always warmer than the lower part. Let us suppose that the temperature varies uniformly along the length of the pendulum.

A reversible pendulum consists of two parts, (first) the part symmetrical about the middle of the pendulum, and (second) the load, however distributed. We may distinguish letters referring to these two parts by the subjacent indices 1 and 2. Letters without an index may refer to the whole pendulum.

Considering, first, the symmetrical part, it is plain that the inequality of temperature cannot sensibly alter the radius of gyration of this about its center of mass, which depends on the mean temperature only, since the center of mass of this part is at the center of the pendulum. The distance of the center of mass from the supporting knife-edge will, however, be increased, say, by  $\sigma$ . Then, if  $M$  stand for mass,  $l$  for the length of the corresponding simple pendulum, and  $h$  for the distance of the centre of mass from the point of support, the moment of inertia will be (neglecting  $\sigma^2$ )

$$Mlh + M_1 l \sigma,$$

that is, it will be multiplied by

$$1 + \frac{M_1 \sigma}{M h}$$

But the moment of gravity will be

$$Mh + M_1 \sigma,$$

so that it will also be multiplied by

$$1 + \frac{M_1 \sigma}{M h}$$

and the period of oscillation, which depends on the ratio of the moment of inertia to the moment of gravity, will not be affected.

Let us now consider the load, which we may suppose to be symmetrical about its middle. Denote the distance of its center from that of the pendulum by  $\eta$ . Let  $\delta\tau$  be the excess of the temperature of the upper knife above that of the lower one. Then  $\frac{\eta}{l} \delta\tau$  will be the difference of temperature of the center of the load from the mean temperature of the pendulum. It will have the *minus* sign with heavy end down, the *plus* sign with heavy end up. Let  $k$  be the coefficient of expansion. Then, every dimension of the load will, owing to the inequality of temperature, be multiplied by

$$1 \mp \frac{\eta}{l} k \delta\tau,$$

where the double sign corresponds to the two positions of the pendulum. The radius of gyration about the center of the load (which we may denote by  $\gamma_2$ ) will be multiplied by the same amount;

and consequently the moment of inertia and the square of the period of oscillation will be multiplied by

$$1 \mp \frac{M_2 \gamma_2^2}{M} \frac{\eta}{hl} \cdot \frac{1}{l} k \delta \tau$$

The middle of the distance from the supporting knife-edge to the center of the load will be at a distance

$$\mp \frac{1}{2} \eta + \frac{1}{4} l$$

above the center of the pendulum in the two positions, and this distance will be

$$\pm \eta + \frac{1}{2} l$$

The inequality of temperature will therefore in both positions raise the centre of the load by

$$\frac{1}{2} \frac{\eta^2 - \frac{1}{4} l^2}{l} k \delta \tau$$

The moment of inertia will therefore be multiplied by

$$1 \mp \frac{M_2}{M} \frac{\eta + \frac{1}{2} l}{l} \frac{\eta^2 - \frac{1}{4} l^2}{hl} k \delta \tau$$

the moment of gravity will be multiplied by

$$1 \mp \frac{M_2}{M} \frac{1}{2} \frac{\eta^2 - \frac{1}{4} l^2}{hl} k \delta \tau$$

and the square of the period of oscillation will be multiplied by

$$1 \mp \frac{M_2}{M} \frac{\eta}{l} \frac{\eta^2 - \frac{1}{4} l^2}{hl} k \delta \tau$$

In order to make these effects as small as possible, the load should be concentrated as much as possible about one knife-edge. For this purpose, the symmetrical part might be an unloaded tube about  $\sqrt{3}$  times the distance between the knife-edges in length. This construction would also have the advantage of eliminating the error due to the flexure of the pendulum staff.

In the case of the Peirce metre pendulums, we have

$$\begin{aligned} \gamma_2^2 &= \frac{1}{4} (3 \text{ cm})^2 + \frac{1}{12} (16.03 \text{ cm})^2 = 23.66 \text{ (cm)}^2 \\ M_2 &= 4000 \text{ grams} & \eta &= 65.63 \text{ cm} & M &= 105000 \text{ grams} \\ h_d &= 75 \text{ cm} & h_u &= 25 \text{ cm} & l &= 100 \text{ cm} & k &= .00001863 & T &= 1.003 \end{aligned}$$

And the correction to the time of 5000 oscillations with heavy end up, or 15000 with heavy end down, per degree centigrade of difference of temperature between the knife-edges is

$$\pm 0.00856.$$

In the case of the Peirce yard pendulum,

$$\begin{aligned} \gamma_2^2 &= \frac{1}{4} (3 \text{ cm})^2 + \frac{1}{12} (15.19 \text{ cm})^2 = 21.48 \text{ (cm)}^2 \\ M_2 &= 3770 \text{ grams} & \eta &= 60.68 \text{ cm} & M &= 10000 \text{ grams} \\ h_d &= 68.58 & h_u &= 22.86 & l &= 91.44 & k &= .00001863 & T &= 0.9594 \end{aligned}$$

and the same correction is

$$\pm 0.00863.$$

## APPENDIX No. 18.

### TRIBUTE TO THE MEMORY OF HENRY W. BLAIR, ASSISTANT.

By the death of Assistant HENRY WAYNE BLAIR the Coast and Geodetic Survey has lost a young officer of marked ability and high character; one of whom it is not too much to say that had he lived he would have stood among the foremost in rank on the work.

Mr. Blair was born in San Antonio, Texas, December 27, 1851. His father was an officer of the Army, on duty there until shortly before the outbreak of the civil war. He then accompanied his parents to Virginia, their native State, and during the trying years that followed, learned in his boyhood lessons of patience, forbearance, and self-denial that were deeply impressed upon him by the privations and sufferings of those times.

In 1866 he was entered as a cadet at the Virginia Military Institute, and took from the first a leading place in scholarship, graduating in 1870 with high rank. Soon after his graduation he was appointed to an assistant professorship in the Institute, and labored in this position with zeal and success, securing the entire confidence of the faculty. He had, however, always desired a life of greater activity than was open to a teacher, and willingly accepted an appointment offered him on the Survey, entering its service as Aid in January, 1872.

The anticipations of usefulness and distinction which his career as a student and professor had led his friends to entertain for him were not long in being fulfilled. In June, 1878, he was promoted to be Subassistant. Continuing to serve with great credit, and exhibiting unusual aptitude in every branch of the work assigned to him, he was made Assistant in August, 1882, having been previously appointed to a position involving laborious and responsible duty in the office. To the duties of this position he devoted himself with unremitting energy, satisfying not only its routine requirements, but following the bent of his mind for work demanding original investigation. He gave much study to the subject of standards of weight and measure, and prepared for publication, in co-operation with the Superintendent, a report on the progress made in the construction of those standards. He submitted designs for, and directed the construction of, a comparing apparatus for the micrometric comparison of standard line measures from a decimeter to a meter in length. To this apparatus was awarded a diploma at the Southern Exposition held at Louisville, where the Survey was represented by an exhibit under Mr. Blair's charge.

In January, 1884, after returning from this service, he resumed his position in the office. It was in the summer of that year that he was taken with a lingering illness, from which late in the autumn he had apparently recovered. He was on his way to New Orleans to take charge of the exhibit of the Survey at the Cotton Centennial Exposition, and had reached Nashville, when a relapse of his disease prostrated his vital powers. He died December 15, 1884.

Mr. Blair's frank, affectionate, and manly nature had endeared him to his comrades; his conscientious and efficient discharge of duty won for him the respect and regard of the older officers with whom he was associated. His ambition was a lofty one; it was not so much to achieve as to deserve success. Deep religious conviction was the guiding force of his whole being, and the very flower and crown of his stainless life. Though lost to us, we have the comforting assurance that he has entered upon higher activities, sustained by an unfaltering trust and cherishing an immortal hope.





## PROGRESS SKETCHES.

- No. 1. Sketch of general progress (eastern sheet).
2. Sketch of general progress (western sheet).
3. Section I and part of Section II. Triangulation between the Saint Croix and Hudson Rivers and Lake Ontario.
4. Part of Section II, Section III, and parts of Sections XIII and XIV. Triangulation between the Hudson River and Cape Henry and the Ohio River.
5. Parts of Sections IV, V, VIII, and XIII. Triangulation between the Maryland and Georgia base lines (southern part), with extension westward, and triangulation in Tennessee.
6. Part of Section VI. East Coast of Florida from Amelia Island to Halifax River.
7. Part of Section VI. West Coast of Florida from Cape Sable to Charlotte Harbor.
8. Parts of Sections VIII and IX. Coast of Mississippi, Louisiana, and Texas. Sub-sketoh of the Rio Grande to Brownsville.
9. Part of Section X. Coast of California from San Diego to Point Sal.
10. Part of Section X. Coast of California from Point Sal to Tomales Bay.
11. Parts of Sections X and XI. Coast of California from Tomales Bay to the Oregon line, and coast of Oregon from the California line to Cape Falcon or False Tillamook.
12. Part of Section XI. Coast of Oregon and Washington Territory from Tillamook Bay to the Boundary.
13. Part of Section XII. Alaska (southeastern coast).
14. Part of Section XIV. Reconnaissance and triangulation in Wisconsin.
15. Parts of Sections III, XIII, XIV, XV, XVI. Progress in the States of West Virginia, Kentucky, Ohio, Indiana, Illinois, Missouri, and Kansas, of the triangulation intended to form a geodetic connection between the Atlantic and Pacific coasts.
16. Part of Sections X and XVI. Progress in the States of California, Nevada, Utah, and Colorado, of the triangulation intended to form a geodetic connection between the Pacific and Atlantic coasts.
17. Map showing longitude stations and connections determined by means of the electric telegraph between 1846 and 1885.
18. Map showing positions of magnetic stations occupied between 1844 and 1885.

## ILLUSTRATIONS.

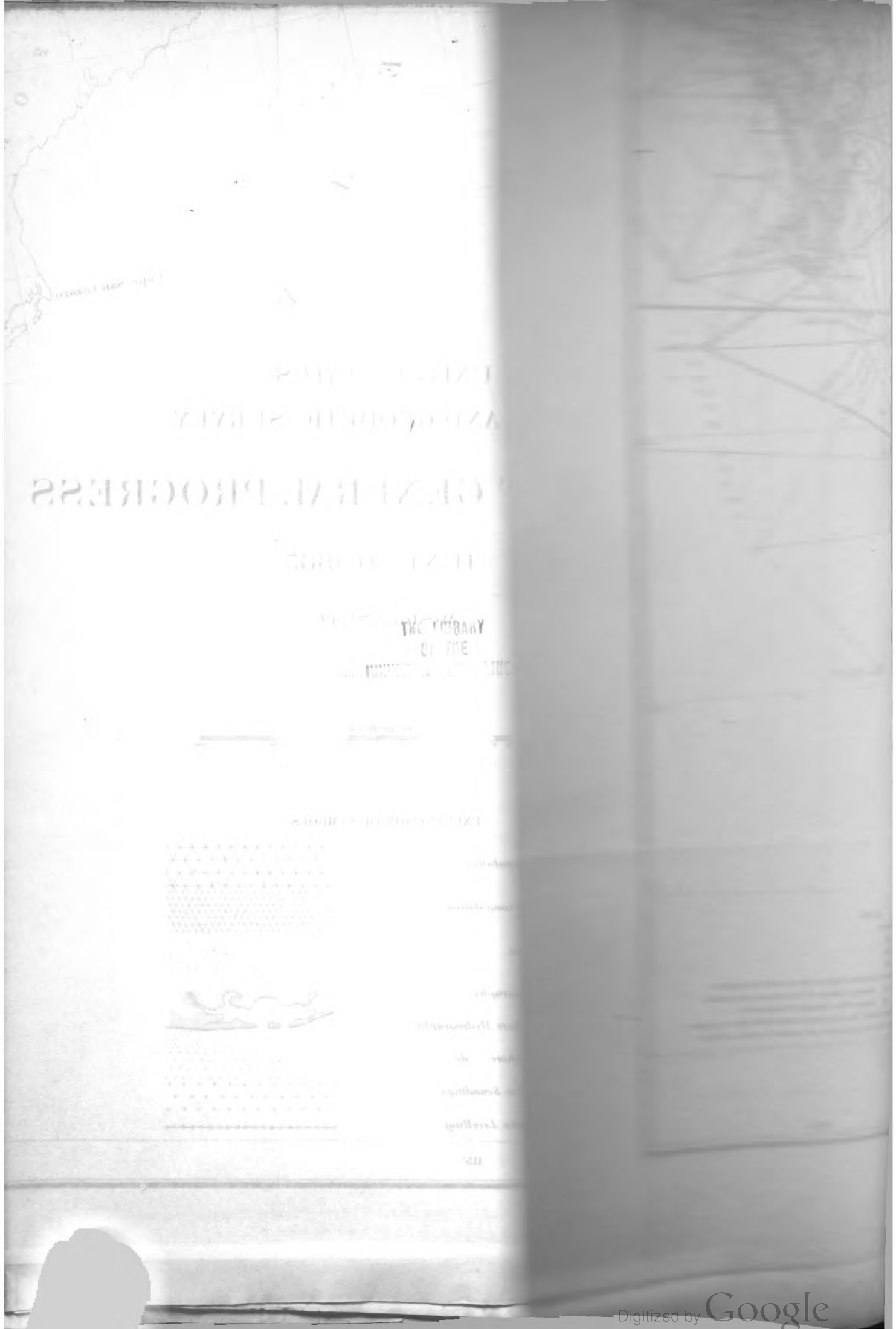
19. To Appendix No. 6. Type-curves of the secular variation of the magnetic dip and of the total intensity. [To face page 264.]
20. To Appendix No. 6. Type-curves of the secular variation of the horizontal intensity. [To face page 270.]
21. To Appendix No. 6. Secular variation in the direction of a freely suspended magnetic needle for the period 1820 to 1885. [To face page 272.]
22. To Appendix No. 6. Isoclinic map of the United States for the year 1885.
23. To Appendix No. 6. Isodynamic (horizontal intensity) map of the United States for the year 1885.
24. To Appendix No. 6. Isodynamic (total intensity) map of the United States for the year 1885.

- No. 25. To Appendix No. 8. Triangulation in Eastern Massachusetts, 1843 to 1885, including State survey by S. Borden, 1832-1838, and triangulation in Rhode Island, 1838-1885.
26. To Appendix No. 8. Triangulation in Western Massachusetts, 1860-1885, including State survey by S. Borden, 1832-1838, and connection with the Hudson River.
27. To Appendix No. 10. Secondary triangulation of Boston Bay. [To face page 480.]
28. To Appendix No. 10. Primary and secondary triangulation near Edisto Base, South Carolina. [To follow No. 27, which faces page 480.]
29. To Appendix No. 12. Transverse sections of the Delaware River between the Old Navy-Yard and the east end of Petty's Island. [To follow page 488.]
30. To Appendix No. 12. Transverse sections of the Delaware Bay between the Old Navy-Yard and the east end of Petty's Island. [To follow page 488.]
31. To Appendix No. 12. Transverse sections of the Delaware Bay between the Old Navy-Yard and the east end of Petty's Island. [To follow page 488.]
32. To Appendix No. 12. Transverse sections of the Delaware Bay between the Old Navy-Yard and the east end of Petty's Island. [To follow page 488.]
33. To Appendix No. 12. Transverse sections of the Delaware Bay between the Old Navy-Yard and the east end of Pett's Island. [To follow page 488.]
34. To Appendix No. 12. Transvers e sections of the Delaware Bay between the Old Navy-Yard and the east end of Petty's Island. [To follow page 488.]
35. To Appendix No. 13. Sketch showing positions of tide-gauges at Governor's Island and Sandy Hook. [To face page 490.]
36. To Appendix No 14. Apparatus devised by Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, for observation of deep-sea currents. [To face page 496.]
37. To Appendix No. 14. Chart showing locality of cross-section "A" deep-sea current work between Fowey Rocks and Gun Cay. [To face page 500.]
38. To Appendix No. 14. Projection showing positions of current stations on cross-section "A." [To follow No. 37.]
39. To Appendix No. 14. Profile of bottom, cross-section "A," and diagram showing variations in velocity of currents with changes in the moon's declination. [To follow Nos. 37 and 38.]
40. To Appendix No. 14. Diagram showing declination and phase of moon at times of observation. [To follow preceding numbers from No. 37 onward.]
41. To Appendix 14. Curves of observation of station No. 1<sup>b</sup>, cross-section "A." [To follow preceding numbers from No. 37 onward.]
42. To Appendix No. 14. Curves of observation at stations 1 $\frac{1}{2}$ <sup>a</sup>, 1<sup>c</sup>, 1<sup>d</sup>, and 1<sup>e</sup>, cross-section "A." [To follow preceding numbers from No. 37 onward.]
43. To Appendix No. 14. Vertical curves and curves of observation at station 1<sup>f</sup>. [To follow preceding numbers from No 37 onward.]
- 44 To Appendix No. 14. Curves of observation at stations 1, 1<sup>a</sup>, 1 $\frac{1}{2}$ , and 2, cross-section "A." [To follow preceding numbers from No. 37 onward.]
45. To Appendix No. 14. Curves of observation at stations 5, 5<sup>a</sup> and 5<sup>b</sup>, and vertical curve at station 5<sup>a</sup>. [To follow preceding numbers from No. 37 onward.]
46. To Appendix No. 14. Curves of observation at stations 3<sup>a</sup>, 3, 4 and 4<sup>a</sup>. [To follow preceding numbers from No 37 onward.]









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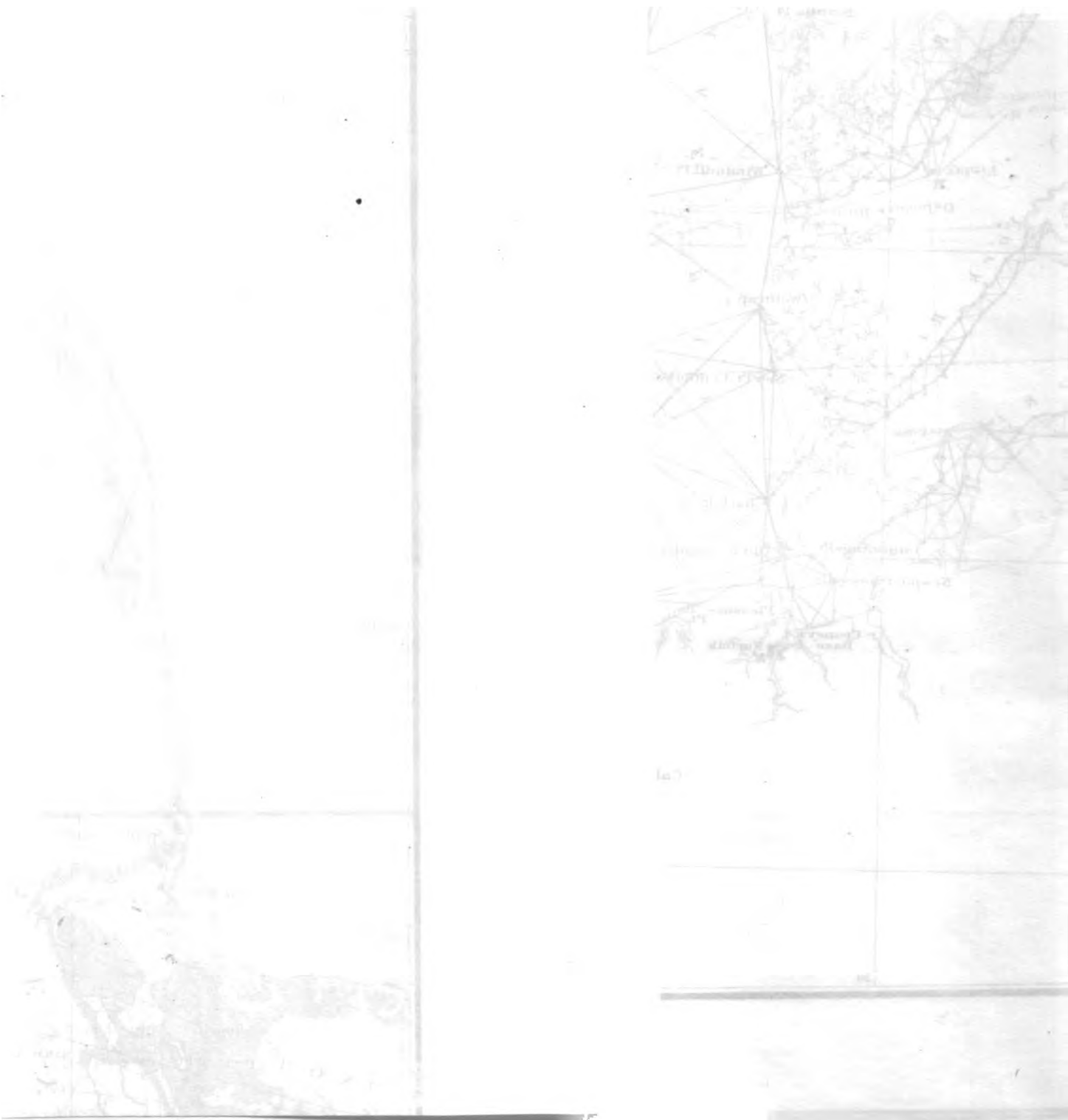
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TO INDICATE THE  
NATURE OF THE  
LAND SURFACE

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CLIFFS  
GLACIERS  
SNOW-COVERED AREAS  
FORESTS  
CITIES AND VILLAGES  
RAILROADS  
ROADS  
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MOUNTAINS  
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EARTHQUAKES  
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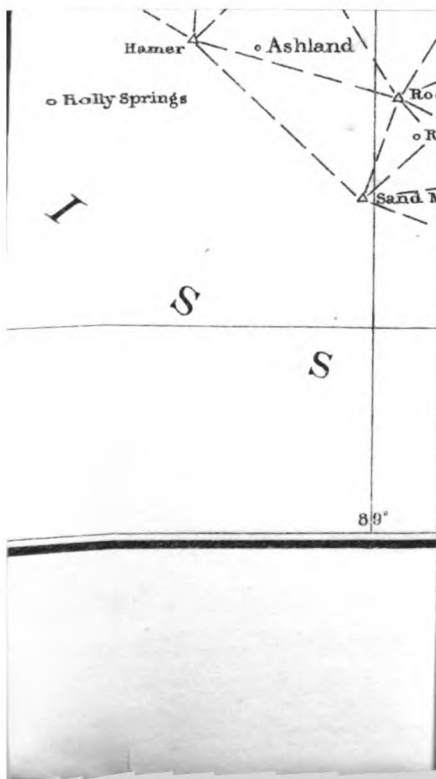








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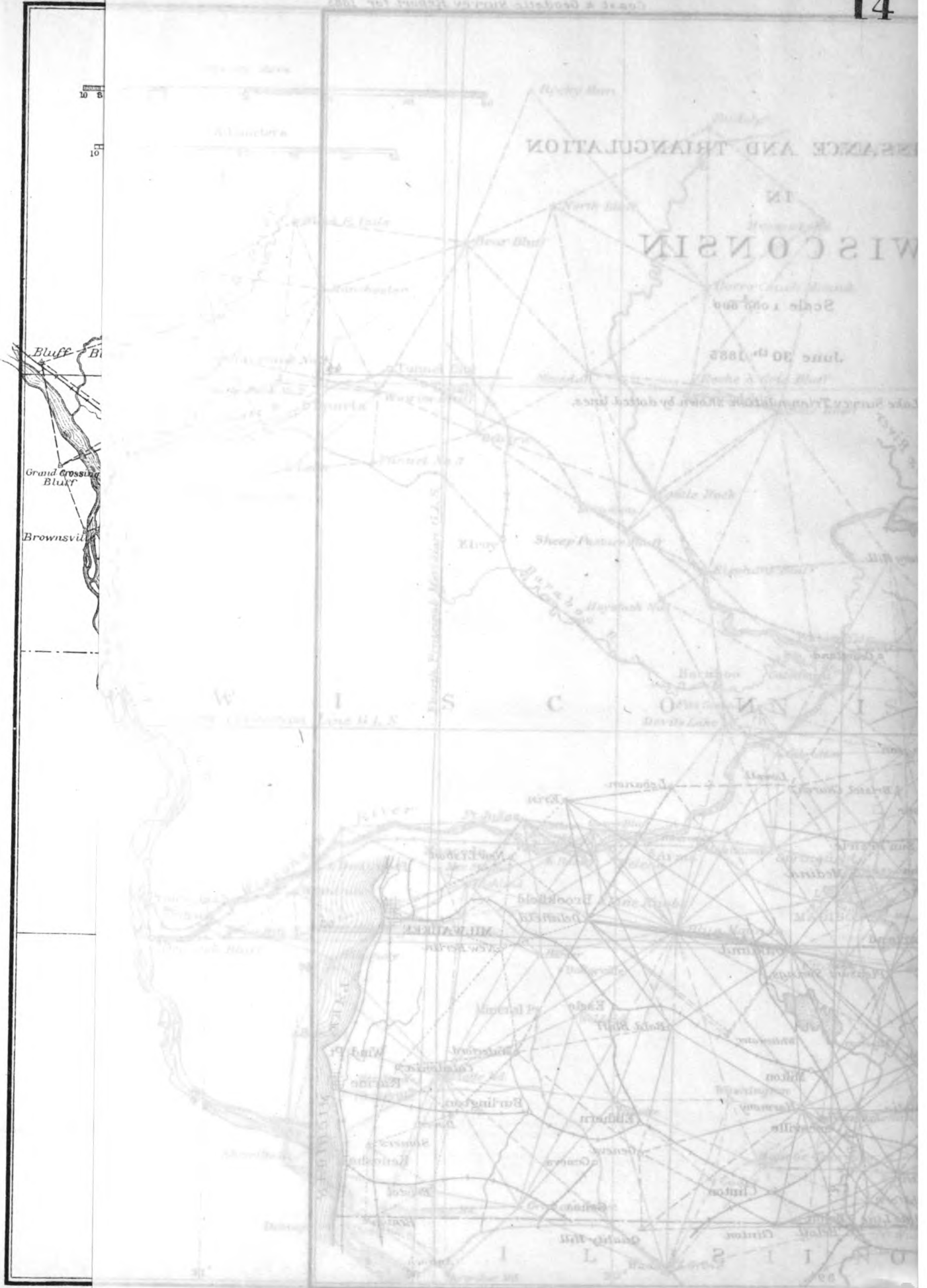
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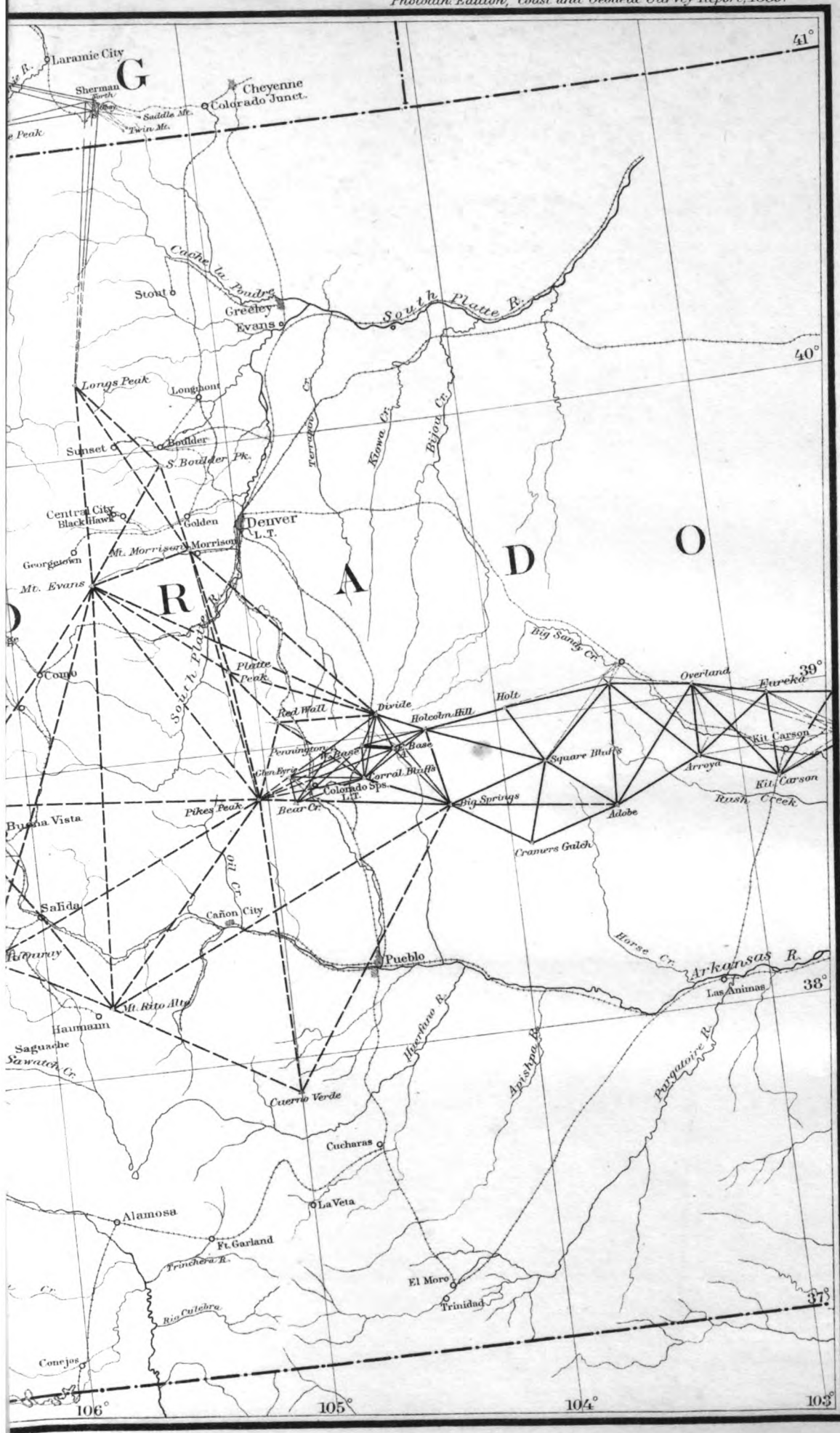




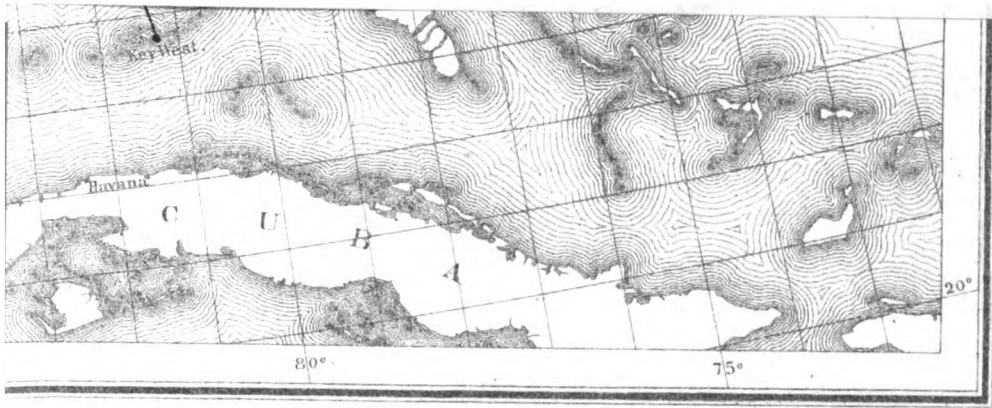




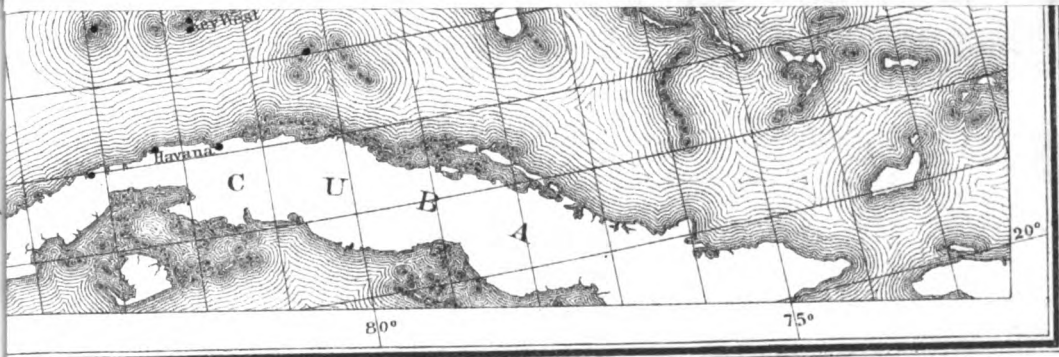
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